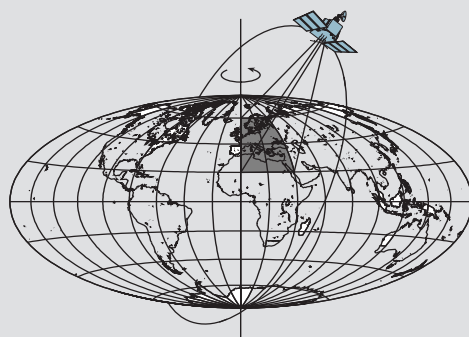


Geometric Constraints in Image Sequence and Neural Networks for Object Recognition

by

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Geometric Constraints in Image Sequences and Neural Networks for Object Recognition

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Geometric Constrains in Image Sequences and Neural Networks for Object Recognition

Summary

Spatially referenced mobile mapping image sequences contain rich information for applications such as transportation and utility management. Automatic object recognition and measurement from the images for reducing human operations and enhancing efficiency is a challenge in mobile mapping data processing. This report describes the research results of the project “Geometric Constrains in Image Sequences and Neural Networks for Object Recognition” supported by CFM/NASA (November 1996 – December 1997). Hopfield neural networks are applied to develop an algorithm for utility object recognition and photogrammetric measurements. Specifically, street light poles are modeled in the 3-D object space and compared with the corresponding features in the image sequences. The neurons of the net are formed by vector edge features from the model and images. The established Hopfield model is able to recognize light poles from a single image. It can also recognize and locate all light poles from the image sequences. It first recognizes all light pole features in the images. Secondly, corresponding light poles in stereo images are identified. Finally, the photogrammetric triangulation supplies 3-D positions of the poles in the object space. Such automation is particularly important for building special layers, for example traffic signs, fire hydrants, and road centerlines, to build GIS databases. The method developed has been successfully tested using mobile mapping image sequences. The major contributions of this research are

- Establishment of a Hopfield neural network for object recognition from mobile mapping image sequences using 3-D object models and 2-D image features,

- Application of the developed model to recognize and locate a specific light pole from a single image and from an image sequence, and to build a 3-D light pole database of all light poles,
- Understanding of the behavior of individual parameters of the neural network and their impact on the recognition results, and
- Development of the N^2M^2 system.

1 Introduction

Mobile mapping technology has been researched and demonstrated an innovative way for large-scale spatial data acquisition. Land vehicle based systems have been commercialized in last few years. A fully digital and real-time airborne mobile mapping system, AIMS (Airborne Integrated Mapping System), is in development at The OSU Center for Mapping (CFM). Examples of major challenging research areas include integrated sensor signal processing, automated triangulation, object recognition for automatic building of 3D databases and extracting features for triangulation, among others. A fundamental issue is image understanding of georeferenced mobile mapping data, which leads to the automatic reconstruction of 3-D objects from 2-D image features.

In existing mobile mapping data processing systems (Bossler et al. 1992, Li et al. 1994, Novak 1995, He 1996, Li 1997), fundamental photogrammetric and other measuring functions, image processing functions (global and local image enhancement), edge detection, area-based matching and zooming, and GIS data input/output functions have been developed. The systems were used for collecting infrastructure data, transportation data and other objects in GIS. Despite of its advantages, the potential of Mobile Mapping technology is currently limited by the following factors:

- Most of data processing is manual,
- The great scale variation causes difficulty in position measurements and object recognition, and
- Geometric constraints provided by the sensors are not fully utilized.

In order to overcome the limits, research on automatic feature extraction and 3-D object recognition have to be conducted. Based on this motivation and the CFM's research priorities, the objectives of this research are:

- To study the correspondence between extracted image features and 3-D object spatial models,
- To develop methods for automatic recognition of specific objects,
- To apply neural networks for object recognition,
- To integrate geometric constraints into neural networks, and
- To develop methods for recognizing and locating objects using multiple images.

2 Methodology

Object recognition and determination of object location have been based on principles of pattern recognition and photogrammetry. To date, object recognition is most efficiently performed by human operators, although measurements can be automated by digital image matching techniques. The human image understanding process has not been fully understood, because of the complexity of the human brain. Therefore, it is so far not possible to simulate the biological process of object recognition by a computer system. Computational approaches have been used in neural networks. It was hoped that a vector based neural network method would solve some of the problems faced by traditional raster based pattern recognition methods when applied in mobile mapping data processing. For example, the recognition algorithm would have to handle extremely large image sequences of mobile mapping data. Furthermore, raster patterns of the same object may vary from image to image because of great scale changes, imaging geometry etc.

Based on above, we were to find a new method for object recognition from mobile mapping image sequences in order for a computer to simulate vision process of a human operator. Artificial neural network was chosen to implement this approach.

2.1 Basic principle of neural networks

A neural network is "a computing system made up of a number of simple, highly interconnected processing elements, which process information by their dynamic state response to external inputs" (Caudill 1989). Unlike popular conception, neural networks do not mimic operations of the human brain. They can be thought of consisting of inter-connected "neurons" linked together by synapses. When enough of the input synapses send a signal into a neuron, it 'fires', causing signals to be sent down its output synapses, which in turn cause other neurons to fire, and so on.

Neural networks are typically organized in layers. Layers are made up of a number of interconnected “nodes” or neurons, which contain an “activation function”. An “input layer” communicates to one or more “hidden layers” where the actual processing is done via a system of the weighted “connections”. The hidden layers then link to an “output layer” where the answer lies. The structure of an artificial neuron is shown in Figure 1.

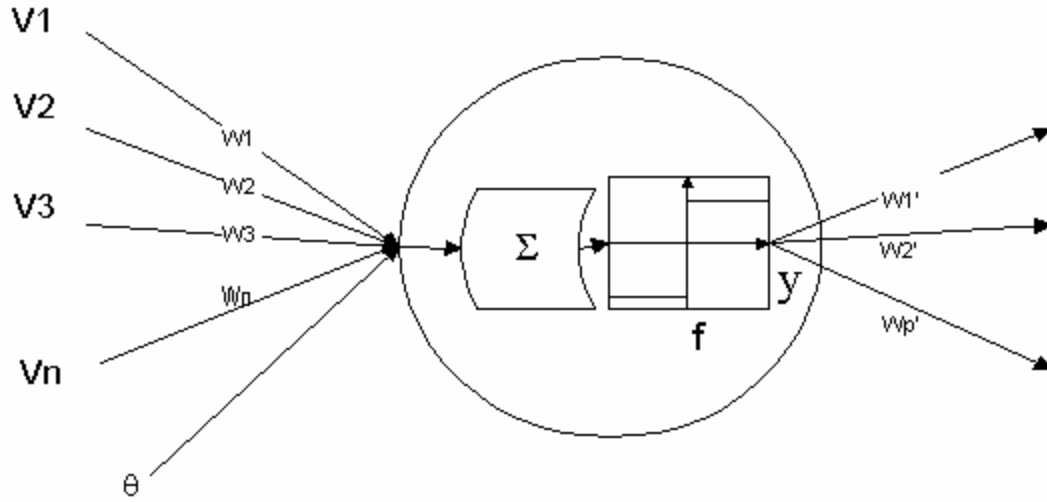


Figure 1. The structure of artificial neuron

The output y of the neuron is expressed as

$$y = f((\sum_i W_i V_i) - q), \quad (1)$$

with

- f - transfer function
- W_i - weight (mimic the strength of synapse)
- V_i - input signal
- q - the threshold.

In comparison to the computer process, human brain has a massively parallel structure, a large knowledge database, and distributed memory. It has capabilities of fuzzy reasoning and learning. Neural networks can be classified into four groups:

- a) Supervised learning network: which involves target values for the network outputs;
- b) Unsupervised learning network: which does not involve the using of target data. Instead of learning an input-output mapping, the goal may be to model the probability distribution of the input data or to discover clusters or other structure in the data;
- c) Associate learning network: which does not involve the whole target data and conclude the result; and
- d) Optimization application network: which requires the minimization of an objective function subject to some constraints.

In a system of d), the object recognition from the mobile mapping data can be treated as an optimization problem to identify an object from different georeferenced stereo images. Hopfield neural network is one of the networks in this group.

2.2 Survey and analysis of neural network software packages

Most neural network methods for pattern recognition are based on raster data. Training data (knowledge or object models) and target data (data to be compared to) are both stored in the raster data format. This requires more computer memory and computational time. Furthermore, the features compared are low-level features so that robustness is often an issue. Improved methods use vector data with objects defined according to various knowledge levels.

Six neural network software systems, namely NeuroSolutions, Neural Networks at your Fingertips, Attrasoft Boltzmann Machine, Windows Neural Networks (WinNN), THINKS-Neural Networks, and SNNS were surveyed. The software packages are developed by the companies or universities. A number of them are available on web pages. Five systems with the Hopfield Model or multilayer processing

functions, including NeuroSolutions, Neural Networks at your Fingertips, Attrasoft Boltzmann Machine, Windows Neural Networks (WinNN), and THINKS-Neural Networks for Windows, were tested. The majority of the systems is based on back-propagation learning and is used for pattern recognition. The survey and test results of the five systems are listed in Table 1.

The neural network objective or energy function is fixed in most software packages reviewed. It cannot be modified, nor additional constraints can be added if source code is not provided. Only two packages, NeuroSolutions and Neural Networks at your Fingertips (NN), came with source code. However, the package handles raster elements instead of vector features as we have in this project. Furthermore, constraints are also vector based and thus, cannot be efficiently integrated into the existing packages. It was then decided that a new software system be developed in this project. The following is the results of the neural network software system review.

NeuroSolutions

There are six levels of NeuroSolutions.

- 1) The Educator, the entry level version, is intended for those who want to learn about neural networks and work with MLPs. Up to 512 neurons per layer and up to 2 hidden layers.
- 2) The Users version extends the Educator with a variety of neural models for static pattern recognition applications. Up to 16K neurons per layer and up to 6 hidden layer.
- 3) The Consultants version offers enhanced models, which support dynamic pattern recognition, time-series prediction and process control problems.

Table 1. The characteristics of the neural network software packages

	NeuroSolutions	Neural Networks at your Fingertips (NN)	Attrasoft Boltzmann Machine(ABM)	Windows Neural Networks (WinNN)	THINKS
Developer or Company	NeuroDimension, Inc.	Karsten Kutza	Attrasoft	Dr. Yaron Danon	Logical Designs Consulting, Inc.
Function	Six levels and allow you to implement your own neural models	Ready-to-reuse software simulators for eight popular architectures	Learn by adapting its synaptic weight to changes in the surrounding	Back-propagation learning and multiple document interface application	With eight learning algorithms and eight Architectures
Hopfield Model	Yes	Yes	Yes(The Boltzman machine)	No	Yes
Single or Multi-layer	Both	Single	Single	Both (2 to 5)	Both (3 hidden layer)
Environment	Win 3.1, 95, NT	DOS	Win 95	Win 3.1	Win 95
Source code	Professional level supports ANSI C++ source code	Support source for each architecture	No	No	No
Image data processing	No	No	No (has to be draw on text file by hands)	No	No
Data input	Text file or import from spreadsheet	Text file	Text file	Text file	Input from software function or import from spreadsheet
Language	C++	C	No	Interface by Visual Basic and calculate by Fortran DLL	Support Windows Dynamic Link Library (DLL)
Graphics	Yes	No	Yes	Yes	Yes

- 4) The Professional version adds ANSI C++ compatible code generation, allowing you to embed NeuroSolutions' algorithms into your own applications (including learning). Furthermore, this version allows any simulation prototyped within NeuroSolutions to be run on other platforms, e.g. faster computers or embedded real time systems.
- 5) The Developer versions allow you to extend the functionality of NeuroSolutions by integrating your own neural network, preprocessing, control, and input/output algorithms.
- 6) NeuroSolutions for Excel is an Excel Add-in that integrates with any of the six levels of NeuroSolutions to provide a very powerful environment for manipulating your data, generating reports, and running batches of experiments.

Systems are required to meet the follows minimum specifications: Operating System of Windows NT 3.51/4.0 or Windows 95, 8MB RAM (16MB recommended), 20MB free hard disc space (6MB for the abbreviated version), video of 640x480 with 256 colors (800x600 with 16M colors recommended).

Neural Networks at your Fingertips

The characteristics of this software package are listed in Table 2. A Hopfield model uses a set of training data to calculate weight values of each neuron in an objective function: $\text{Sum} = \sum W * V_i$, where $V_i = -1$ if $\text{Sum} < \text{threshold}$, otherwise $V_i = 1$. Each model has independent code. The user can modify the code to develop own programs.

Table 2. Characteristics of Neural Networks at your Fingertips
(Abstract from web page: <http://www.geocities.com/CapeCanaveral/1624/>)

Network	Application	Description
ADALINE Adaline Network	Pattern Recognition Classification of Digits 0-9	The Adaline is essentially a single-layer back propagation network. It is trained on a pattern recognition task, where the aim is to classify a bitmap representation of the digits 0-9 into the corresponding classes. Due to the limited capabilities of the Adaline, the network only recognizes the exact training patterns. When the application is ported into the multi-layer back propagation network, a remarkable degree of fault-tolerance can be achieved.
BPN Back propagation Network	Time-Series Forecasting Prediction of the Annual Number of Sunspots	This program implements the now classic multi-layer back propagation network with bias terms and momentum. It is used to detect structure in time-series which is presented to the network using a simple tapped delay-line memory. The program learns to predict future sunspot activity from historical data collected over the past three centuries. To avoid over fitting, the termination of the learning procedure is controlled by the so-called stopped training method.
HOPFIELD Hopfield Model	Auto associative Memory Associative Recall of Images	The Hopfield model is used as an auto associative memory to store and recall a set of bitmap images. Images are stored by calculating a corresponding weight matrix. Thereafter, starting from an arbitrary configuration, the memory will settle on exactly that stored image, which is nearest to the starting configuration in terms of Hamming distance. Thus given an incomplete or corrupted version of a stored image, the network is able to recall the corresponding original image.
BAM Bi-directional Associative Memory	Hetero associative Memory Association of Names and Phone Numbers	The bi-directional associative memory can be viewed as a generalization of the Hopfield model to allow for a Hetero associative memory to be implemented. In this case, the association is between names and corresponding phone numbers. After coding the set of exemplars, the network, when presented with a name, is able to recall the corresponding phone number and vice versa. The memory even shows a limited degree of fault-tolerance in case of corrupted input patterns.
BOLTZMAN Boltzmann Machine	Optimization Traveling Salesman Problem	The Boltzmann machine is a stochastic version of the Hopfield model; whose network dynamics incorporate a random component in correspondence with a given finite temperature. Starting with a high temperature and gradually cooling down, allowing the network to reach equilibrium at any step, chances are good, that the network will settle in a global minimum of the corresponding energy function. This process is called simulated annealing. The network is then used to solve a well-known optimization problem: The weight matrix is chosen such that the global minimum of the energy function corresponds to a solution of a particular instance of the traveling salesman problem.
CPN Counter propagation Network	Vision Determination of the Angle of Rotation	The counter propagation network is a competitive network designed to function as a self-programming lookup table with the additional ability to interpolate between entries. The application is to determine the angular rotation of a rocket-shaped object, images of which are presented to the network as a bitmap pattern. The performance of the network is a little limited due to the low resolution of the bitmap.
SOM Self-Organizing Map	Control Pole Balancing Problem	The self-organizing map is a competitive network with the ability to form topology-preserving mappings between its input and output spaces. In this program the network learns to balance a pole by applying forces at the base of the pole. The behavior of the pole is simulated by numerically integrating the differential equations for its law of motion using Euler's method. The task of the network is to establish a mapping between the state variables of the pole and the optimal force to keep it balanced. This is done using a reinforcement learning approach: For any given state of the pole the network tries a slight variation of the mapped force. If the new force results in better control, the map is modified, using the pole's current state variables and the new force as a training vector.
ART1 Adaptive Resonance Theory	Brain Modeling Stability-Plasticity Demonstration	This program is mainly a demonstration of the basic features of the adaptive resonance theory network, namely the ability to plastically adapt when presented with new input patterns while remaining stable at previously seen input patterns.

Attrasoft Boltzmann Machine

The Boltzmann Machine is a neural network whose behavior can be described statistically in terms of a very simple rule. This rule is as follows: let a synaptic connection from neuron i to neuron j , at time t , be $M[i, j][t]$, then the connection at the next time $t + 1$, $M[i, j][t + 1]$, is $M[i, j][t + 1] = M[i, j][t] + a(q[i, j] - p[i, j] + \dots)$

where a is a small number; $q[i, j]$ represents the correlation between neuron i and neuron j from the training data; and $p[i, j]$ represents a self-created correlation between neuron i and neuron j . The Boltzmann Machine supports up to 65,000 external (input/output) neurons. It learns by interactive training and continues to learn by interactive retraining. It also works for any pattern recognition problem; for example, image recognition. The system includes more than twenty examples, including one with more than 4,000 classes. It is capable of learning more than 4,000 characters in 60 seconds, a speed unachievable by humans. It recognizes 1 of the 4,000 characters in 0.5 seconds and supports translation and scaling symmetries.

The Neural Network Capabilities include:

- Character Recognition: To recognize a character, a network of 1000-neurons or so is required. A character can be represented by a 20-by-20-pixel image (400 neurons). The rest of the neurons can be used to identify up to 600 different characters in 1-neuron-1-class mode, or about 180,000 characters in 2-neuron-1-class mode.
- Signature Recognition: To recognize a signature, a network of 3000-neurons or so is required. A signature can be represented by a 20-by-100-pixel image (2000 neurons). The rest of the neurons can

be used to identify up to 1000 different signatures in 1-neuron-1-class mode, or about 500,000 signatures in 2-neuron-1-class mode.

- Image Recognition: To recognize an image, a network of 20,000-neurons or so is required. An image can be preprocessed to the size of 100-by-100-pixel (10,000 neurons). The rest of the neurons can be used to identify up to 10,000 different images in 1-neuron-1-class mode, or about 50,000,000 images in 2-neuron-1-class mode.

Windows Neural Networks (WinNN)

Windows Neural Networks (WinNN) is a windows based Neural Network (NN) simulator with back-propagation learning. The following is a brief description of feed forward NNs that helps understand the way WinNN calculates and adjust the weights. A neural network in its basic form is composed of several layers of neurons: an input layer, one or more hidden layers and an output layer. Each layer of neurons receives its input from the previous layer or from the network input. The output of each neuron feeds the next layer or the output of the network. Mathematically the network computes:

- 1) The output of the hidden layer (treating the bias as another input): $h(j) = \text{Sum}(w(i,j) * i(i), i=1, 3)$ and $s(j) = f(h(j))$,
- 2) For the output layer calculate: $h'(k) = \text{Sum}(w'(j,k) * s(j), j=1, 3)$ and $O(k) = f(h'(k))$, where: $i(i)$ are the network inputs, $O(k)$ are the network outputs, $W(i,j)$ represents the weight connecting neuron i in layer 1 to neuron j in layer 2, $W'(j,k)$ represents the weight connecting neuron j in layer 2 to neuron k in layer 3, and $f(x)$ is the neuron transfer function, for example, a sigmoid: $f(x) = 1/(1 + \exp(-x))$.

Training such a network involves using a database of examples, which are values of the input and output of the NN. The NN would learn by adjusting the weights to minimize the error of the outputs. The error function is the objective of the minimization procedure and defined as: $SSE = \sum_{p=1}^{Pmax} \sum_{k=1}^{Kmax} (t(p,k) - O(p,k))^2$, where $O(p,k)$ is the NN output k for pattern p , and $t(p,k)$ is the output training pattern p for output k . The reported RMS Error is calculated as $RMS = \sqrt{SSE / Pmax}$. WinNN uses a simple back propagation algorithm to adjust the weights. This algorithm is an iterative one. WinNN trains in BATCH mode with a variable EPOCH length. That is it sums the weight adjacent over all the training patterns in an epoch and then adjusts the weights.

THINKS-Neural Networks for Windows

This software program supports eight Neural Network Learning Rules: Back Propagation (BPN), Quick Propagation (QP), Jacobs Enhanced Back Propagation, Kohonen Winner Take All, Simulated Annealing (SA), Recurrent Back Propagation, Learning Vector Quantization, and Cascade Correlation. The available architecture types are Multi layer Normal Feed Forward, Multi layer Full Feed Forward, Total Recurrent, Prior Recurrent, Cascade, and Cascade Recurrent. The network error type determines how error is computed. Since the goal of neural network training is to minimize error, the network error type method affects weight adjustments and specifically how outliers are handled.

2.3 Basic principle of Hopfield neural network for mobile mapping

A Hopfield neural network has the follows key behaving elements:

- It is completely described by a state vector $V = (v_1, v_2, \dots, v_n)$ of all neurons;
- There are a specific set of stable states $V_s = (v_1, v_2, \dots, v_n)$ that correspond to the stored patterns;
- and
- The system evolves in time from any arbitrary starting state V_0 to a stable state V_s by decreasing its energy E .

A Hopfield neural network is built from a single layer of neurons (units), with feedback connections from each unit to every other unit (except itself). The change of the unit states is associated to an energy function. A Hopfield neural network for vector image matching uses a two-dimensional array for storing V . The rows represent features of the vector image with an object used as a template or an object model defined a priori. The columns represent features of another image where the object defined will be recognized. Figure 2 shows an example of a two-dimensional state array.

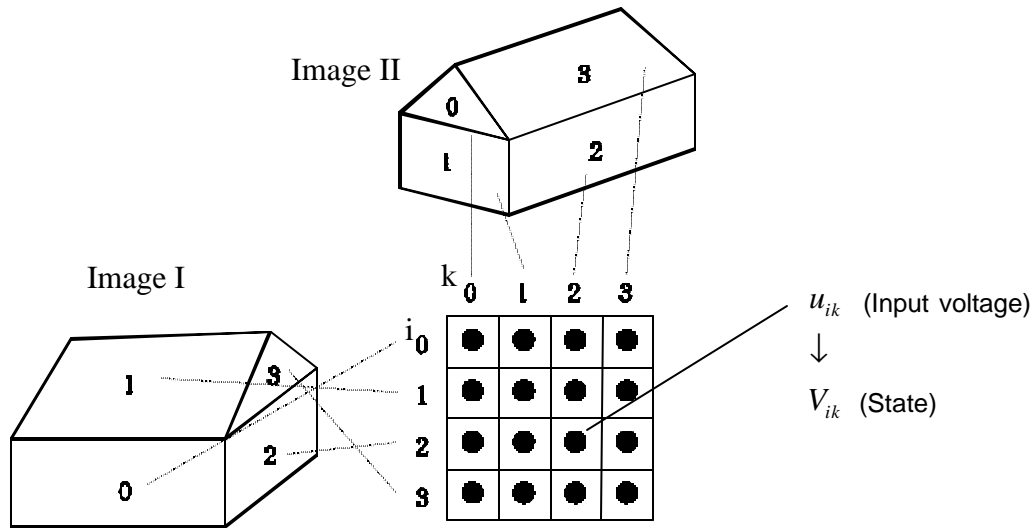


Figure 2. A Hopfield neural network of two-dimensional array for storing V

Face features in Image I are numbered $i=1,2,3$ and 4. These in Image II are $j=1,2,3$ and 4. Faces 2 and 3 may not be the same faces of 0 and 1 in image II because of the orientation of cameras. The Hopfield neural network is to find the corresponding faces between the images. Such correspondences are represented in the state array of V where a high correspondence between face i in image I and face j in Image II is expressed by a high state value v_{ij} of neuron (i, j) . The final state V_s is obtained by an optimization of an energy function defined as

$$E = -\sum_i \sum_k \sum_j \sum_l C_{ikjl} V_{ik} V_{jl} + \sum_i (1 - \sum_k V_{ik})^2 + \sum_k (1 - \sum_i V_{ik})^2 \quad (2)$$

where the first term is a compatibility constraint; the second and third terms are the uniqueness constraints. v_{ij} converges to 1.0 if face i in Image I matches face k in Image II. Otherwise, it is greater than or equal to 0. C_{ikjl} is the strength of interconnection between a neuron (row i and column k) and another neuron (row j and column l):

$$C_{ikjl} = \sum_n W_n * F(x_n, y_n) \quad (3)$$

where

x_n is the n -th measuring feature of the unit (row i and column k),

y_n is the n -th measuring feature of the unit (row j and column l),

W_n is a weight, $\sum W_n = 1$ and the transfer function is

$$F(x, y) = \begin{cases} 1 & \text{if } |x - y| < q \\ -1 & \text{otherwise} \end{cases}.$$

q is a threshold value. It is the measuring features that represent characteristics of objects to be recognized. Examples of the measuring features may be shape similarity, orientation consistency, and conformance to constraints. If measuring features from the two images do not match, through the threshold, the transfer function, and the weights, the energy function in Equation (2) will be penalized

by a large value. Otherwise, the features will have a less contribution to the energy function. In an application, it is very important to design the detailed measuring features, the weights, and threshold values. The terms of energy are separated into two groups and are given different weights. Group 1 is the first term. Group 2 contains the second and third terms. Two weight coefficients p_1 and p_2 ($p_1 + p_2 = 1$) are given to the groups:

$$E = p_1 [-\sum_i \sum_k \sum_j \sum_l C_{ijkl} V_{ik} V_{jl}] + p_2 [\sum_i (1 - \sum_k V_{ik})^2 + \sum_k (1 - \sum_i V_{ik})^2]. \quad (4)$$

If we increase the weight of group 2, p_2 , it will enhance the effect of $\sum (1 - \sum V)^2$. In this case, only one feature of row or column will be matched. A high value of p_1 will allow a feature in a row to match multiple features in columns. The optimal state of the conjugate relations between the two groups is reached when the minimum energy value is obtained. The minimization of Equation (4) is performed by updating the state array V iteratively.

The above basic model is used to recognize street light poles from the mobile mapping data.

2.4 Enhancement of the accuracy of recognized objects using multiple images

Once an object is recognized in stereo images, its 3-D coordinates can be calculated by a photogrammetric intersection of two conjugate image features. The accuracy and reliability of the coordinates can be enhanced if multiple (more than two) images are used. The basic principle of the multiple image intersection using the mobile mapping data is shown in Figure 3. In this simplified case, there are three pairs of stereo exposure centers and one object position.

The object may appear in several images in the sequence. The strategy of automatic determination of the 3-D object location from multiple images is described in the following.

Step 1. The desired object is automatically recognized in all individual images by the Hopfield neural network. This is completed by comparing the object image features with the known model in the 3-D object space.

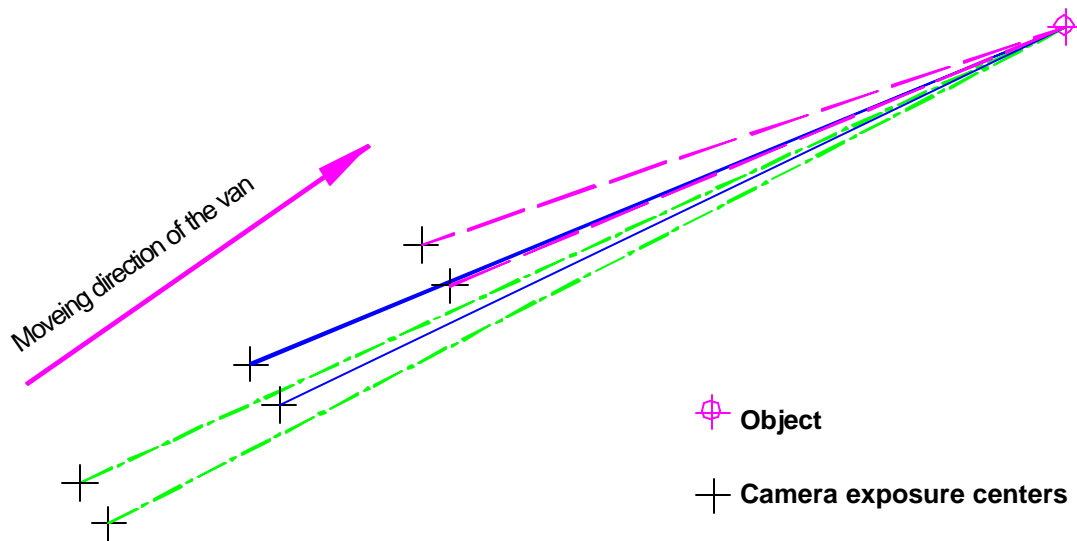


Figure 3. Multiple image intersection

Step 2. Conjugate image features that are recognized in Step 1 are automatically determined in all images. The combinations of stereo pairs are restricted to any two images within three immediately adjacent exposure stations. The result of this step is 3D locations of objects calculated by photogrammetric triangulation. So far the triangulation is done pair wise. A simultaneous estimation of the location from all available images should be used in the future.

Step 3. A thematic database is built automatically by applying the algorithm through all the images in the sequence.

3. Hopfield Neural Network for Mobile Mapping Data Processing

In this research, it was decided that street light poles are our targeted objects for recognition. In the 3-D object space, a light pole is defined as a cylinder with a diameter of 21.2cm and a length of 6.795m. The values were obtained by manual photogrammetric measurements of light poles from the images of the project area. It should stand vertically not far from the mobile mapping van. Such a light pole is then back projected onto the images and used to find out images features similar to them. Conjugate light pole image features are recognized and used to calculate 3-D locations.

3.1 Measuring features and weights

The 3-D light pole model is defined in the object space. It is back projected onto the image space using the camera orientation parameters. The measuring features evaluate differences between the back projected pole lines and image features. The Hopfield network makes judgement if the object (light pole) described by the model exists in the images through Equation (4). The measuring features used in this research can be separated into two groups, namely local features and relational features. They are both defined in the image space. The local features include

- Length (λ): length of a line,
- Azimuth (α): azimuth of a line (measured clockwise from the x-axis),
- Distance (δ): distance between two lines, and
- Local Gradient (+1 or -1)_{ik}: east-west gradient (+1 for the case from background to the interior of the line pair, -1 otherwise).

The relational features are

- Relative angle (β): angle from the first line to the line linking the middle points of the line pair (clockwise),
- Ratio (δ/λ): width-height ratio, and
- Relative Gradient (+1 or -1)_{ikjl}: relative gradient defined similar to the local gradient feature.

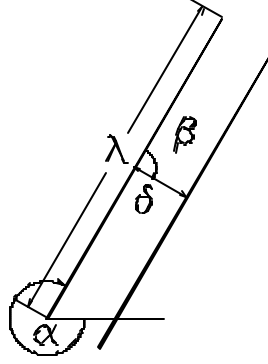


Figure 4. Definition of a pair of lines

The Hopfield neural network uses different combinations of the above features in the model to recognize poles in different situations. To recognize a specific light pole with a known position in the object space, we use the measuring features of

- Length of lines (scale variant),
- Azimuth of lines (close to vertical), and
- Local Gradient (compatibility of a line pair to form a pole).

The weights of p_1 and p_2 of the two energy groups are initially set equal in the energy function. Numerical values of the measuring features can be calculated and analyzed to determine thresholds (q) and weights (W_n). A partial differential equation is used to link the updated neuron states and the energy decrease/increase in Equation (4). The equation is solved iteratively.

To recognize all light poles regardless positions, the measuring features used are:

- Width-length ratio (scale invariant),
- Azimuth of lines (close to scale invariant), and
- Relative Gradient (compatibility of a line pair to form a pole, scale invariant)

3.2 Data sets

Data in the object space: The first set of data describes the light poles. A light pole is defined as a cylinder with a given length and radius. The approximate coordinates of the bottom central point are estimated using camera orientation parameters. The second set of data is camera orientation parameters. They come from the mobile mapping data and are used for transformation between the object and image spaces.

Data in the image space: The line features in images are supposed to be extracted by digital image processing. At this time, the operator manually extracts them. Each line has a label ID, coordinates of its vertices, a starting node and an end node, and a gradient of the line (1 for the case that the left-hand side is darker than the right and -1 otherwise).

3.3 Algorithm for light pole recognition

The following steps depict the algorithm developed in this project for recognizing the light poles from mobile mapping data:

Step 1. Create a matrix with a dimension of $I \times M$ (I is the number of back projected model lines and M is the number of line features in the image) to store neuron states V . Figure 5 shows an example of extracted lines from an image and a pair of lines back-projected from a light pole model in the object space.

Step 2. Set the initial states of V as

$$V_{ik}^0 = g(u_{ik}^0) = [1 + \exp(-2u_{ik}^0 / u_0)]^{-1}$$

$$u_{ik}^0 = u_{init} + d = u_0 + d$$

where $u_0 = 0.002$ and d is a random number uniformly distributed between $0.1 u_0$ and $+0.1 u_0$.

u_{ik} is called input voltage.

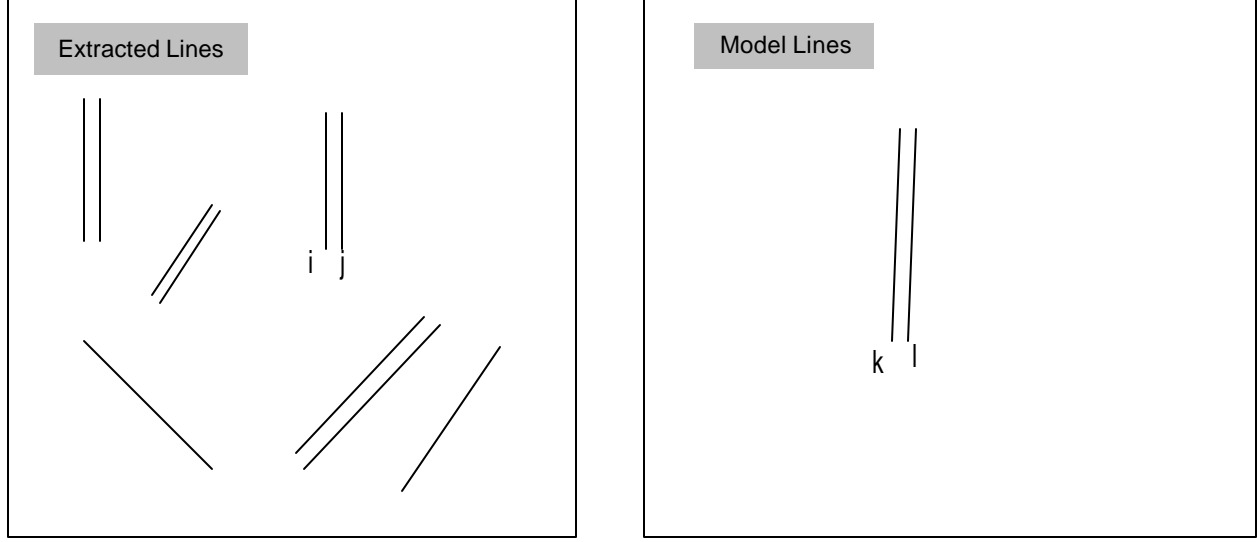


Figure 5 Extracted lines from an image and back-projected lines from a light pole model

Step 3. Build C coefficients (see Equation (4))

$$\begin{aligned}
 C_{ikjl} = & W_1 * F(d_{I_i, I_j}, d_{M_k, M_l}) + W_2 * F(a_{I_i}, a_{M_k}) + W_3 * F(a_{I_j}, a_{M_l}) \\
 & + W_4 * F(I_{I_i}, I_{M_k}) + W_5 * F(I_{I_j}, I_{M_l}) + W_6 * F(Grad_{I_i}, Grad_{M_k}) \\
 & + W_7 * F(Grad_{I_j}, Grad_{M_l}) + W_8 * F(Grad_{I_i}, Grad_{M_k}, Grad_{I_j}, Grad_{M_l})
 \end{aligned}$$

The features with subscriptions of I and M are those of the model and image, respectively; d is the distance between two lines; a_i means the azimuth of a line: $\arctan [(X_E^i - X_B^i) / (Y_E^i - Y_B^i)]$; I_i stands for the length of a line: $\sqrt{(X_E^i - X_B^i)^2 + (Y_E^i - Y_B^i)^2}$; Grad defines the gradient of lines; and F is a transfer function in Equation (3); further, W_i are weight factors of the features, $\sum W_i = 1$. They are set as $W_2 = W_3$, $W_4 = W_5$, $W_6 = W_7 = W_8 / 2$. The weights are adjusted according to the objects to be recognized and the images. Note that $F(x, y) = 0$ if $i = j$ or $k = l$.

Step 4. Set the current number of iteration as $t=1$ and the limit of iterations as n .

Step 5. Update the values of u_{ik} and V_{ik}

for (i=0; i<m; i++)

for (k=0; k<n; k++)

$$u_{ik}^{t+1} = u_{ik}^t + \frac{1}{6} (K_1 + 2 * K_2 + 2 * K_3 + K_4)$$

where

$$K_1 = h \times f(u_{ik}^t) = h \times (\sum_j \sum_l C_{ikjl} V_{jl}^t - \sum_l V_{il}^t - \sum_j V_{jk}^t - u_{ik}^t / 1 + 2)$$

$$K_2 = h \times f(u_{ik}^t + \frac{1}{2} K_1)$$

$$K_3 = h \times f(u_{ik}^t + \frac{1}{2} K_2)$$

$$K_4 = h \times f(u_{ik}^t + K_3)$$

h is a constant (h=0.0001)

Step 6. $V_{ik}^{t+1} = g(u_{ik}^{t+1})$ and repeat Step 5 until $t \geq n$. Update $V_{ik} = \begin{cases} 1 & \text{if } V_{ik} > 0.5 = \mathbf{q}_1 \\ 0 & \text{otherwise} \end{cases}$

4. Results and Analysis

4.1 Test data sets

Two test data sets acquired by two different Mobile Mapping Systems are used. The data sets include digital stereo image sequences, positions and attitudes of the cameras (internal and external orientation parameters of each image). One system provides the format of color digital images (720 pixels \times 400 pixels). The other system has the format of gray scale images (512 pixels \times 480 pixels). For reducing the volume of the images, we transferred the color images to gray scale images. Figure 6 shows a sample of a pair of digital stereo images.



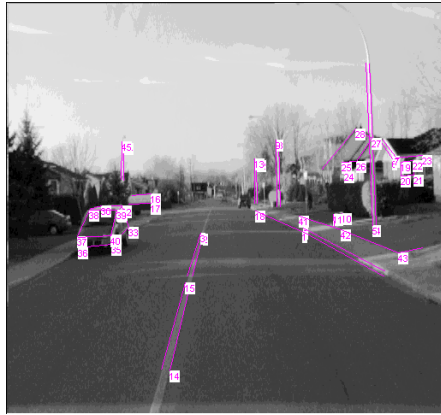
Figure 6. A digital stereo image pair

As another example, the labeled line features overlaid on the original image and the original itself are shown in Figure 7. The extracted image lines and the back projection of the 3-D pole model are shown in Figure 8. Among the image lines, lines 4 and 5, 8 and 9, 12 and 13, and 44 and 45 are pairs of edge lines of light poles. Lines 44 and 45 represent a partial light pole.

4.2 Experiment and analysis

Once the model is defined, the most important thing is to determine the parameters in the model. In this section, we describe the results of three experiments, namely recognition of a specific light pole, recognition of all light poles, and location of recognized light poles using multiple images. In the first two experiments, we discuss the effect of the parameters in the neural network, including thresholds and

weights. In the third experiment, accuracy of reconstructed light poles and the location distribution will be analyzed.

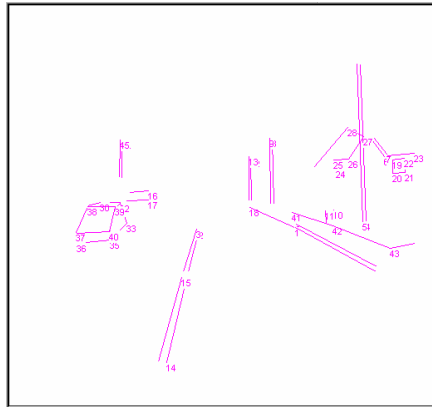


Labeled line features

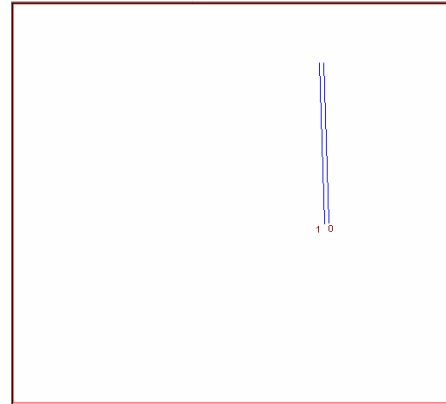


Original Image

Figure 7. Labeled line features and the original image



Extracted line features



Back projection of the model

Figure 8. Extracted lines and the back-projection of the model

The software system developed in this project allows the user to change the parameters through the system interface shown in Figure 9.

image pole lines 4 and 5 in the image. In the process, the Hopfield network generates a layer of 2 by 46 neurons to match 2 model lines with 46 image lines from the image. Table 3 listed states of neurons indicating the recognition result.

Each measuring feature (length, azimuth, or local gradient) has an equal weight. The weight of each neural element was also assigned with an equal weight. The following parameters were used:

Threshold of $\lambda=4.0$	Weight of $\lambda=0.25$
Threshold of $\alpha=3.0$	Weight of $\alpha=0.25$
Threshold of $\delta=4.0$	Weight of $\delta=0.25$
Threshold of $\beta=90$ or 270	Weight of $\beta=0.00$
Threshold of $\delta/\lambda=0.05$	Weight of $\delta/\lambda=0.00$
Threshold of gradient=0	Weight of gradient=0.25
$p_1=0.5$	$p_2=0.5$

ID of extracted line	0	1	2	3	4	5	6	7	8	9	10	11
Neuron state (Matching with model line 0)	0	0	0	0	1	0	0	0	0.46	0	0.22	0
Neuron state (Matching with model line 1)	0	0	0	0	0	1	0	0	0	0.49	0	0.26
	12	13	14	15	16	17	18	19	20	21	22	23
	0.46	0	0	0	0	0	0	0.22	0	0	0	0
	0	0.49	0	0	0	0	0	0	0	0.26	0	0
	24	25	26	27	28	29	30	31	32	33	34	35
	0	0	0	0	0	0	0	0	0	0	0.22	0
	0	0	0	0	0	0	0	0	0	0	0	0
	36	37	38	39	40	41	42	43	44	45		
	0	0	0	0	0	0	0	0	0.46	0		
	0	0	0	0	0	0	0	0	0	0.49		

Table 3. Final states (v_{ik}) of the neurons (recognition of a specific pole)

The state V_{ik} gives a value ranging from 0 to 1, with 1 indicating a perfect match between the model line i and image line k , and 0 being no match at all between them. Observing Table 3, the system has clearly recognized the image pole lines 4 and 5 since $V_{0,4} = V_{1,5} = 1$. Other image pole lines, such as 8-9, 12-13, and 44-45, have relatively high state values (close to 0.5) because they are similar to the model lines 0-1 (Figure 8) except the length. An experiment is also carried out to observe the behavior of system in response to changes of the parameters. This is accomplished by changing the selected parameter(s) and

executing the program each time. The effect of such changes is reflected in the final states of the neurons.

Example 1. Changing threshold λ from 4.00 to 2.00

The change of the threshold λ from 4.00 to 2.00 means a more strict constraint in accepting candidates in terms of the length of image lines. This resulted in a decrease of the state value in Table 4, except $V_{0,4}$ which remains the same. $V_{1,5}$ reduced from 1 to 0.75, which is still a high value. The parameters used are:

Threshold of $\lambda=2.00$	Weight of $\lambda=0.25$
Threshold of $\alpha=3.00$	Weight of $\alpha=0.25$
Threshold of $\delta=4.00$	Weight of $\delta=0.25$
Threshold of $\beta=90$ or 270	Weight of $\beta=0.00$
Threshold of $\delta/\lambda=0.05$	Weight of $\delta/\lambda=0.00$
Threshold of gradient=0	Weight of gradient=0.25
$p_1=0.5$	$p_2=0.5$

ID of extracted line	0	1	2	3	4	5	6	7	8	9	10	11
Neuron state (Matching with model line 0)	0	0	0	0	1	0	0	0	0.41	0	0.18	0
Neuron state (Matching with model line 1)	0	0	0	0	0	0.75	0	0	0	0.46	0	0.26
	12	13	14	15	16	17	18	19	20	21	22	23
	0.41	0	0	0	0	0	0	0.18	0	0	0	0
	0	0.46	0	0	0	0	0	0	0	0.26	0	0
	24	25	26	27	28	29	30	31	32	33	34	35
	0	0	0	0	0	0	0	0	0	0	0.18	0
	0	0	0	0	0	0	0	0	0	0	0	0
	36	37	38	39	40	41	42	43	44	45		
	0	0	0	0	0	0	0	0	0.41	0		
	0	0	0	0	0	0	0	0	0	0.46		

Table 4. Final states V of the neurons (threshold λ changed to 2.00)

Example 2. Changing threshold λ from 4.00 to 6.00

The threshold λ is changed to 6.00 to allow candidates to have lines with different lengths. The parameters used are:

Threshold of $\lambda=6.00$	Weight of $\lambda=0.25$
Threshold of $\alpha=3.00$	Weight of $\alpha=0.25$
Threshold of $\delta=4.00$	Weight of $\delta=0.25$
Threshold of $\beta=90$ or 270	Weight of $\beta=0.00$
Threshold of $\delta/\lambda=0.05$	Weight of $\delta/\lambda=0.00$
Threshold of gradient=0	Weight of gradient=0.25
$p_1=0.5$	$p_2=0.5$

ID of extracted line	0	1	2	3	4	5	6	7	8	9	10	11
Neuron state (Matching with model line 0)	0	0	0	0	1	0	0	0	0.46	0	0.22	0
Neuron state (Matching with model line 1)	0	0	0	0	0	1	0	0	0	0.49	0	0.26
	12	13	14	15	16	17	18	19	20	21	22	23
	0.46	0	0	0	0	0	0	0.22	0	0	0	0
	0	0.49	0	0	0	0	0	0	0	0.26	0	0
	24	25	26	27	28	29	30	31	32	33	34	35
	0	0	0	0	0	0	0	0	0	0	0.22	0
	0	0	0	0	0	0	0	0	0	0	0	0
	36	37	38	39	40	41	42	43	44	45		
	0	0	0	0	0	0	0	0	0.46	0		
	0	0	0	0	0	0	0	0	0	0.49		

Table 5. Final states V of the neurons (threshold λ changed to 6.00)

The results listed in Table 5 do not have significant difference from Table 3 which used threshold $\lambda=0.4$. Comparing the results with the extracted lines in Figure 8, it is clear that the length differences between model lines 0-1 and image lines 8-9, 12-13, and 44-45 are significant. Therefore, the threshold change did not cause any great effect on the result.

Example 3. Changing threshold α from 3.00 to 1.00

The parameters used are:

Threshold of $\lambda=4.00$	Weight of $\lambda=0.25$
Threshold of $\alpha=1.00$	Weight of $\alpha=0.25$
Threshold of $\delta=4.00$	Weight of $\delta=0.25$
Threshold of $\beta=90$ or 270	Weight of $\beta=0.00$
Threshold of $\delta/\lambda=0.05$	Weight of $\delta/\lambda=0.00$
Threshold of gradient=0	Weight of gradient=0.25
$p_1=0.5$	$p_2=0.5$

The change of the threshold from 3.0 to 1.0 means increased constraints on verticality of the lines. This resulted in the more acceptances of light poles in Table 6. The model lines of 0-1 matched both 4-5 and 8-9. A major difference between 4-5 and 8-9 is their lengths. But the weights for length λ and azimuth α are the same 0.25. The threshold of α is tighter (more important). Thus, the significance of the length is reduced and the system accepted both 4-5 and 8-9 as matches of model lines 0-1.

ID of extracted line	0	1	2	3	4	5	6	7	8	9	10	11
Neuron state (Matching with model line 0)	0	0	0	0	0.87	0	0	0	0.87	0	0	0
Neuron state (Matching with model line 1)	0	0	0	0	0	0.97	0	0	0	0.97	0	0
	12	13	14	15	16	17	18	19	20	21	22	23
	0.4	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	24	25	26	27	28	29	30	31	32	33	34	35
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	36	37	38	39	40	41	42	43	44	45		
	0	0	0	0	0	0	0	0	0	0		
	0	0	0	0	0	0	0	0	0	0		

Table 6. Final states V of the neurons (threshold α changed to 1.00)

Example 4. Changing threshold α from 3.00 to 5.00

The parameters used are:

Threshold of $\lambda=4.00$	Weight of $\lambda=0.25$
Threshold of <u>$\alpha=5.00$</u>	Weight of $\alpha=0.25$
Threshold of $\delta=4.00$	Weight of $\delta=0.25$
Threshold of $\beta=90$ or 270	Weight of $\beta=0.00$
Threshold of $\delta/\lambda =0.05$	Weight of $\delta/\lambda =0.00$
Threshold of gradient=0	Weight of gradient=0.25
$p_1=0.5$	$p_2=0.5$

Setting $\alpha=5.00$ gives lower restrict to verticality of lines, so that the fact that 8-9 is much shorter than the model lines 0-1 is counted heavily again. This explains why $V_{0,8}$ and $V_{1,9}$ decreased to 0.45 in Table 7.

ID of extracted line	0	1	2	3	4	5	6	7	8	9	10	11
Neuron state (Matching with model line 0)	0	0	0	0	1	0	0	0	0.45	0	0.23	0
Neuron state (Matching with model line 1)	0	0	0	0	0	1	0	0	0	0.45	0	0.23
	12	13	14	15	16	17	18	19	20	21	22	23
	0.45	0	0	0	0	0	0	0.23	0	0	0	0
	0	0.45	0	0	0	0	0	0	0	0.23	0	0
	24	25	26	27	28	29	30	31	32	33	34	35
	0	0	0	0	0	0	0	0	0	0	0.23	0
	0	0	0	0	0	0	0	0	0	0	0	0
	36	37	38	39	40	41	42	43	44	45		
	0	0	0	0	0	0	0	0	0.45	0		
	0.23	0	0	0	0	0	0	0	0	0.45		

Table 7. Final states V of the neurons (threshold α changed to 5.00)Example 5: Changing threshold δ from 4.00 to 2.00

The parameters used are:

Threshold of $\lambda=4.00$	Weight of $\lambda=0.25$
Threshold of $\alpha=3.00$	Weight of $\alpha=0.25$
Threshold of <u>$\delta=2.00$</u>	Weight of $\delta=0.25$
Threshold of $\beta=90$ or 270	Weight of $\beta=0.00$
Threshold of $\delta/\lambda=0.05$	Weight of $\delta/\lambda=0.00$
Threshold of gradient=0	Weight of gradient=0.25
$p_1=0.5$	$p_2=0.5$

Changing the threshold δ from 4.00 to 2.00 does not affect the result (Table 8). This is because the distances between image pole lines are smaller than 2.00 pixel.

ID of extracted line	0	1	2	3	4	5	6	7	8	9	10	11
Neuron state (Matching with model line 0)	0	0	0	0	1	0	0	0	0.58	0	0.28	0
Neuron state (Matching with model line 1)	0	0	0	0	0	1	0	0	0	0.61	0	0.32
	12	13	14	15	16	17	18	19	20	21	22	23
	0.28	0	0	0	0	0	0	0.28	0	0	0	0
	0	0.32	0	0	0	0	0	0	0	0.32	0	0
	24	25	26	27	28	29	30	31	32	33	34	35
	0	0	0	0	0	0	0	0	0	0	0.28	0
	0	0	0	0	0	0	0	0	0	0	0	0
	36	37	38	39	40	41	42	43	44	45		
	0	0	0	0	0	0	0	0	0.28	0		
	0	0	0	0	0	0	0	0	0	0.32		

Table 8. Final states V of the neurons (threshold δ changed to 2.00)

Example 6. Weight distribution: $p_1=0.6$ and $p_2=0.4$

The parameters used are:

Threshold of $\lambda=4.00$	Weight of $\lambda=0.25$
Threshold of $\alpha=3.00$	Weight of $\alpha=0.25$
Threshold of $\delta=4.00$	Weight of $\delta=0.25$
Threshold of $\beta=90$ or 270	Weight of $\beta=0.00$
Threshold of $\delta/\lambda=0.05$	Weight of $\delta/\lambda=0.00$
Threshold of gradient=0	Weight of gradient=0.25
$p_1=0.6$	$p_2=0.4$

p_1 and p_2 are weights balancing the two energy groups in Equation (4). Increasing p_1 allows a model line to match multiple images lines, while increasing p_2 encourages a unique match between the model lines and image lines. However, p_1 and p_2 are constrained by $p_1 + p_2 = 1$. Since $p_1=0.6$ is greater than $p_2=0.4$ in this example, we see that in addition to high values of $V_{0,4} = 1$ and $V_{1,5} = 1$, $(V_{0,8}, V_{1,9})$, $(V_{0,12}, V_{1,13})$, and $(V_{0,44}, V_{1,45})$ are relatively large.

ID of extracted line	0	1	2	3	4	5	6	7	8	9	10	11
Neuron state (Matching with model line 0)	0	0	0	0	1	0	0	0	0.83	0	0.2	0
Neuron state (Matching with model line 1)	0	0	0	0	0	1	0	0	0	0.85	0	0.24
	12	13	14	15	16	17	18	19	20	21	22	23
	0.83	0	0	0	0	0	0	0.2	0	0	0	0
	0	0.85	0	0	0	0	0	0	0	0.24	0	0
	24	25	26	27	28	29	30	31	32	33	34	35
	0	0	0	0	0	0	0	0	0	0	0.2	0
	0	0	0	0	0	0	0	0	0	0	0	0
	36	37	38	39	40	41	42	43	44	45		
	0	0	0	0	0	0	0	0	0.83	0		
	0	0	0	0	0	0	0	0	0	0.85		

Table 9. Final states V of the neurons ($p_1=0.6$ and $p_2=0.4$)Example 7. Weight distribution: $p_1=0.4$ and $p_2=0.6$

The parameters used are:

Threshold of $\lambda=4.00$	Weight of $\lambda=0.25$
Threshold of $\alpha=3.00$	Weight of $\alpha=0.25$
Threshold of $\delta=4.00$	Weight of $\delta=0.25$
Threshold of $\beta=90$ or 270	Weight of $\beta=0.00$
Threshold of $\delta/\lambda=0.05$	Weight of $\delta/\lambda=0.00$
Threshold of gradient=0	Weight of gradient=0.25
$p_1=0.4$	$p_2=0.6$

Setting p_1 and p_2 the other way around, $p_1=0.4$ and $p_2=0.6$, it requires that each model line matches only one image line. Because the model lines 0-1 are most similar to image lines 4-5, the corresponding neuron states $v_{0,4}$ and $v_{1,5}$ are 1. Conversely, the states of other neurons are low. The effect of adjusting the ratio of p_1 and p_2 is very significant.

ID of extracted line	0	1	2	3	4	5	6	7	8	9	10	11
Neuron state (Matching with model line 0)	0	0	0	0	1	0	0	0	0.32	0	0.2	0
Neuron state (Matching with model line 1)	0	0	0	0	0	1	0	0	0	0.34	0	0.24
	12	13	14	15	16	17	18	19	20	21	22	23
	0.32	0	0	0	0	0	0	0.2	0	0	0	0
	0	0.34	0	0	0	0	0	0	0	0.24	0	0
	24	25	26	27	28	29	30	31	32	33	34	35
	0	0	0	0	0	0	0	0	0	0	0.2	0
	0	0	0	0	0	0	0	0	0	0	0	0
	36	37	38	39	40	41	42	43	44	45		
	0	0	0	0	0	0	0	0	0.32	0		
	0	0	0	0	0	0	0	0	0	0.34		

Table 10. Final states V of the neurons ($p_1=0.4$ and $p_2=0.6$)

Experiment II. Recognition of all light poles

In this experiment, it is expected that the model lines will match all image pole lines. By observing the image pole lines, it is clear that the lengths of the pole lines are different because of the perspective projection. In order for the model lines to match all the pole lines, the contributing measuring features should not include scale variant items. Thus, the weights of λ (length) and δ (width) were set to 0. The applied measuring features include α (azimuth), λ/δ (width-length ratio), and gradient.

The parameters used are:

Threshold of $\lambda=4.00$	Weight of $\lambda=0.00$
Threshold of $\alpha=3.00$	Weight of $\alpha=0.25$
Threshold of $\delta=4.00$	Weight of $\delta=0.00$
Threshold of $\beta=90$ or 270	Weight of $\beta=0.00$
Threshold of $\delta/\lambda=0.05$	Weight of $\delta/\lambda=0.50$
Threshold of gradient=0	Weight of gradient=0.25
$p_1=0.5$	$p_2=0.5$

ID of extracted line	0	1	2	3	4	5	6	7	8	9	10	11
Neuron state (Matching with model line 0)	0	0	0	0	0.98	0	0	0	0.98	0	0.02	0
Neuron state (Matching with model line 1)	0	0	0	0	0	0.98	0	0	0	0.98	0	0.02
	12	13	14	15	16	17	18	19	20	21	22	23
	0.98	0	0	0	0	0	0	0.02	0	0	0	0
	0	0.98	0	0	0	0	0	0	0	0.02	0	0
	24	25	26	27	28	29	30	31	32	33	34	35
	0	0	0	0	0	0	0	0	0	0	0.02	0
	0	0	0	0	0	0	0	0	0	0	0	0
	36	37	38	39	40	41	42	43	44	45		
	0	0	0	0	0	0	0	0	0.98	0		
	0	0	0	0	0	0	0	0	0	0.98		

Table 11. Final neuron states using scale invariant measuring features

According to Table 11, the neural network recognized all light poles correctly by indicating matches of model lines 0-1 with image pole lines of 4-5, 8-9, 12-13, and 44-45. Similar to Experiment I, effects of each parameter on the final recognition results are investigated by changing values of parameters and by observing the final neuron states.

Example 1. Changing threshold of α from 3.00 to 1.00

The parameters used are:

Threshold of $\lambda=4.00$	Weight of $\lambda=0.00$
Threshold of $\alpha=1.00$	Weight of $\alpha=0.25$
Threshold of $\delta=4.00$	Weight of $\delta=0.00$
Threshold of $\beta=90$ or 270	Weight of $\beta=0.00$
Threshold of $\delta/\lambda=0.05$	Weight of $\delta/\lambda=0.50$
Threshold of gradient=0	Weight of gradient=0.25
$p_1=0.5$	$p_2=0.5$

Changing of the threshold of α from 3.00 to 1.00 requires the more strict constraint of azimuths of the image pole lines (ranging from 89° to 91°). The image pole lines were digitized on screen and include digitizing errors. The strict azimuth constraint eliminated the match possibilities of image pole lines of 4-5 and 44-45.

ID of extracted line	0	1	2	3	4	5	6	7	8	9	10	11
Neuron state (Matching with model line 0)	0	0	0	0	0	0	0	0	1	0	0	0
Neuron state (Matching with model line 1)	0	0	0	0	0	0	0	0	0	1	0	0
	12	13	14	15	16	17	18	19	20	21	22	23
	1	0	0	0	0	0	0	0	0	0	0	0
	0	0.87	0	0	0	0	0	0	0	0	0	0
	24	25	26	27	28	29	30	31	32	33	34	35
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	36	37	38	39	40	41	42	43	44	45		
	0	0	0	0	0	0	0	0	0	0		
	0	0	0	0	0	0	0	0	0	0		

Table 12. Final neuron states by changing α to 1.00Example 2. Changing threshold of α from 3.00 to 5.00

The parameters used are:

Threshold of $\lambda=4.00$	Weight of $\lambda=0.00$
Threshold of $\underline{\alpha}=5.00$	Weight of $\alpha=0.25$
Threshold of $\delta=4.00$	Weight of $\delta=0.00$
Threshold of $\beta=-1.00$	Weight of $\beta=0.00$
Threshold of $\delta/\lambda=0.05$	Weight of $\delta/\lambda=0.50$
Threshold of gradient=0	Weight of gradient=0.25
$p_1=0.5$	$p_2=0.5$

Making the constraint of the threshold of α looser ($\alpha=5.0^\circ$) in this example leads to matches of the model lines with all image pole lines. Thus, all poles are recognized.

ID of extracted line	0	1	2	3	4	5	6	7	8	9	10	11
Neuron state (Matching with model line 0)	0	0	0	0	0.95	0	0	0	0.95	0	0.05	0
Neuron state (Matching with model line 1)	0	0	0	0	0	0.95	0	0	0	0.95	0	0.05
	12	13	14	15	16	17	18	19	20	21	22	23
	0.95	0	0	0	0	0	0	0.05	0	0	0	0
	0	0.95	0	0	0	0	0	0	0	0.05	0	0
	24	25	26	27	28	29	30	31	32	33	34	35
	0	0	0	0	0	0	0	0	0	0	0.05	0
	0	0	0	0	0	0	0	0	0	0	0	0
	36	37	38	39	40	41	42	43	44	45		
	0	0	0	0	0	0	0	0	0.95	0		
	0.05	0	0	0	0	0	0	0	0	0.95		

Table 13. Final neuron states by changing α to 5.00Example 3. Changing threshold of δ/λ from 0.05 to 0.02

The parameters used are:

Threshold of $\lambda=4.00$	Weight of $\lambda=0.00$
Threshold of $\alpha=3.00$	Weight of $\alpha=0.25$
Threshold of $\delta=4.00$	Weight of $\delta=0.00$
Threshold of $\beta=90$ or 270	Weight of $\beta=0.00$
Threshold of $\delta/\lambda=0.02$	Weight of $\delta/\lambda=0.50$
Threshold of gradient=0	Weight of gradient=0.25
$p_1=0.5$	$p_2=0.5$

Increasing the constraint of the threshold of δ/λ to 0.02 means that long image poles will be preferred. As the result the partial pole 44-45 and the farthest pole 12-13, which may be covered on the bottom were not matched because of their large width-length ratios.

ID of extracted line	0	1	2	3	4	5	6	7	8	9	10	11
Neuron state (Matching with model line 0)	0	0	0	0	1	0	0	0	1	0	0.29	0
Neuron state (Matching with model line 1)	0	0	0	0	0	1	0	0	0	1	0	0.33
	12	13	14	15	16	17	18	19	20	21	22	23
	0.29	0	0	0	0	0	0	0.29	0	0	0	0
	0	0.33	0	0	0	0	0	0	0	0.33	0	0
	24	25	26	27	28	29	30	31	32	33	34	35
	0	0	0	0	0	0	0	0	0	0	0.29	0
	0	0	0	0	0	0	0	0	0	0	0	0
	36	37	38	39	40	41	42	43	44	45		
	0	0	0	0	0	0	0	0	0.29	0		
	0	0	0	0	0	0	0	0	0	0.33		

Table 14. Final neuron states by changing δ/λ to 0.02Example 4. Changing threshold of δ/λ from 0.05 to 0.08

The parameters used are:

Threshold of $\lambda=4.00$	Weight of $\lambda=0.00$
Threshold of $\alpha=3.00$	Weight of $\alpha=0.25$
Threshold of $\delta=4.00$	Weight of $\delta=0.00$
Threshold of $\beta=90$ or 270	Weight of $\beta=0.00$
Threshold of $\delta/\lambda=0.08$	Weight of $\delta/\lambda=0.50$
Threshold of gradient=0	Weight of gradient=0.25
$p_1=0.5$	$p_2=0.5$

The looser constraint of the threshold of $\delta/\lambda=0.08$ resulted in the same result as $\delta/\lambda=0.05$. All poles are recognized.

ID of extracted line	0	1	2	3	4	5	6	7	8	9	10	11
Neuron state (Matching with model line 0)	0	0	0	0	0.98	0	0	0	0.98	0	0.02	0
Neuron state (Matching with model line 1)	0	0	0	0	0	0.98	0	0	0	0.98	0	0.02
	12	13	14	15	16	17	18	19	20	21	22	23
	0.98	0	0	0	0	0	0	0.02	0	0	0	0
	0	0.98	0	0	0	0	0	0	0	0.02	0	0
	24	25	26	27	28	29	30	31	32	33	34	35
	0	0	0	0	0	0	0	0	0	0	0.02	0
	0	0	0	0	0	0	0	0	0	0	0	0
	36	37	38	39	40	41	42	43	44	45		
	0	0	0	0	0	0	0	0	0.98	0		
	0	0	0	0	0	0	0	0	0	0.98		

Table 15. Final neuron states by changing δ/λ to 0.08

Example 5. Weight distribution: $p_1=0.6$ and $p_2=0.4$

The parameters used are:

Threshold of $\lambda=4.00$	Weight of $\lambda=0.00$
Threshold of $\alpha=3.00$	Weight of $\alpha=0.25$
Threshold of $\delta=4.00$	Weight of $\delta=0.00$
Threshold of $\beta=90$ or 270	Weight of $\beta=0.00$
Threshold of $\delta/\lambda=0.05$	Weight of $\delta/\lambda=0.50$
Threshold of gradient=0	Weight of gradient=0.25
$p_1=0.6$	$p_2=0.4$

Similar to example 6 in Experiment I, the high value of $p_1=0.6$ allows multiple matches between the model lines and the image pole lines. The four image pole lines have the state value 1. But other image lines of 10, 11, 19, and 21 were assigned relatively high state values also.

ID of extracted line	0	1	2	3	4	5	6	7	8	9	10	11
Neuron state (Matching with model line 0)	0	0	0	0	1	0	0	0	1	0	0.57	0
Neuron state (Matching with model line 1)	0	0	0	0	0	1	0	0	0	1	0	0.67
	12	13	14	15	16	17	18	19	20	21	22	23
	1	0	0	0	0	0	0	0.57	0	0	0	0
	0	1	0	0	0	0	0	0	0	0.67	0	0
	24	25	26	27	28	29	30	31	32	33	34	35
	0	0	0	0	0	0	0	0	0	0	0.57	0
	0	0	0	0	0	0	0	0	0	0	0	0
	36	37	38	39	40	41	42	43	44	45		
	0	0	0	0	0	0	0	0	1	0		
	0	0	0	0	0	0	0	0	0	1		

Table 16. Final neuron states with $p_1=0.6$ and $p_2=0.4$

Example 6. Weight distribution: $p_1=0.4$ and $p_2=0.6$

The parameters used are:

Threshold of $\lambda=4.00$	Weight of $\lambda=0.00$
Threshold of $\alpha=3.00$	Weight of $\alpha=0.25$
Threshold of $\delta=4.00$	Weight of $\delta=0.00$
Threshold of $\beta=90$ or 270	Weight of $\beta=0.00$
Threshold of $\delta/\lambda=0.05$	Weight of $\delta/\lambda=0.50$
Threshold of gradient=0	Weight of gradient=0.25
$p_1=0.4$	$p_2=0.6$

The high weight of $p_2=0.6$ discourages the multiple matches. As the result, all the state values are lower. Because only scale invariant measuring features are used and the measuring feature values of the image pole lines are all within the thresholds, the image pole lines are still the ones, which best match the model lines. However, their state values are low, although relatively higher than others.

ID of extracted line	0	1	2	3	4	5	6	7	8	9	10	11
Neuron state (Matching with model line 0)	0	0	0	0	0.55	0	0	0	0.55	0	0.18	0
Neuron state (Matching with model line 1)	0	0	0	0	0	0.57	0	0	0	0.57	0	0.21
	12	13	14	15	16	17	18	19	20	21	22	23
	0.55	0	0	0	0	0	0	0.18	0	0	0	0
	0	0.57	0	0	0	0	0	0	0	0.21	0	0
	24	25	26	27	28	29	30	31	32	33	34	35
	0	0	0	0	0	0	0	0	0	0	0.18	0
	0	0	0	0	0	0	0	0	0	0	0	0
	36	37	38	39	40	41	42	43	44	45		
	0	0	0	0	0	0	0	0	0.55	0		
	0	0	0	0	0	0	0	0	0	0.57		

Table 17. Final neuron states with $p_1=0.4$ and $p_2=0.6$ **Experiment III. Object recognition using multiple images:**

In this experiment, a sequence of 25 images from a mobile mapping survey line are used (Figure 11). Exposure stations of stereo images taken simultaneously by the mobile mapping system are indicated by the ++ symbol, and the exposure station are numbered from 102 to 127. The two stereo images at the same station are distinguished by its station number with a L (left) or R (right) extension, for example, 112L and 112R. Six light poles, from LP1 to LP6, are marked by symbols. The exposure station or images are listed for each light pole that appears in the listed images. Using the method described in Experiment II, the extracted image pole lines in all images are recognized. Considering effective baselines of different possible combinations of stereo pairs, for each pole, only three stations that are closest to the pole are used. For example, light pole LP2 in Figure 11 is covered by exposure stations 102, 103, 104, 105, 106, 107, and 108. However, only three stations (106, 107, and 108) are used to determine the position of the pole.

To start the location process, the station closest to the pole (in this example, 108) is first considered. In either image at station 108, for instance 108L, the longest image pole line pair is automatically selected. The image coordinates of the pole bottom and pole top are known as (x_b, y_b) and (x_t, y_t) . Their corresponding coordinates in the object space are (X_B, Y_B, Z_B) and (X_T, Y_T, Z_T) . Assume that the pole

is vertical and the pole length is l , we have $X_T = X_B$, $Y_T = Y_B$, and $Z_T = Z_B + l$. Since the camera orientation parameters are known, there are four collinearly equations:

$$\begin{aligned} x_b &= -f \frac{a_{11}(X_B - X_0) + a_{12}(Y_B - Y_0) + a_{13}(Z_B - Z_0)}{a_{31}(X_B - X_0) + a_{32}(Y_B - Y_0) + a_{33}(Z_B - Z_0)}, \\ y_b &= -f \frac{a_{21}(X_B - X_0) + a_{22}(Y_B - Y_0) + a_{23}(Z_B - Z_0)}{a_{31}(X_B - X_0) + a_{32}(Y_B - Y_0) + a_{33}(Z_B - Z_0)}, \\ x_t &= -f \frac{a_{11}(X_B - X_0) + a_{12}(Y_B - Y_0) + a_{13}(Z_B + l - Z_0)}{a_{31}(X_B - X_0) + a_{32}(Y_B - Y_0) + a_{33}(Z_B + l - Z_0)}, \text{ and} \\ y_t &= -f \frac{a_{21}(X_B - X_0) + a_{22}(Y_B - Y_0) + a_{23}(Z_B + l - Z_0)}{a_{31}(X_B - X_0) + a_{32}(Y_B - Y_0) + a_{33}(Z_B + l - Z_0)}. \end{aligned} \quad (5)$$

In the above four equations, there are three unknowns (X_B, Y_B, Z_B) which can be solved by a least squares adjustment. The coordinates are then used to back project a 3-D pole model to the right image 108R. The two back projected model lines are then used to match the image pole lines on the right image using the method of the neural network described in Experiment I. Once the correct image pole lines in the right image are found, the precise position of the pole in the object space can be calculated by a photogrammetric intersection. To obtain a more precise location of the pole in the object space by multiple image intersection, the pole location calculated from the station 108 is used to back project the 3-D model onto all images of three stations (106L, 106R, 107L, 107R, 108L, and 108R). The neural network is used again to find corresponding image pole lines in the selected stereo images of various combinations. At this stage, the coordinates of the pole from different stereo pair are calculated and compared. Intersections using all qualified images will be implemented in the future. In this way, all light poles in the image sequence can be recognized and located subsequently.

Table 18 presents the coordinates of the light pole LP2 calculated by 11 combinations of stereo image pairs. The corresponding plot of the locations of the pole is in Figure 12. Ideally, the locations should be within a small area. However, because of the relatively short effective baselines the calculated locations are spread along the track (Figure 12). In the middle of all the locations is the point calculated from the stereo pair of 108L and 108R which is the station closest to the pole. Two image pairs, namely 107L & 108R and 107R & 108R, are far away from the average location. It should be noted that their intersection angles and their effective baselines are both very small. Thereby the large errors are caused.

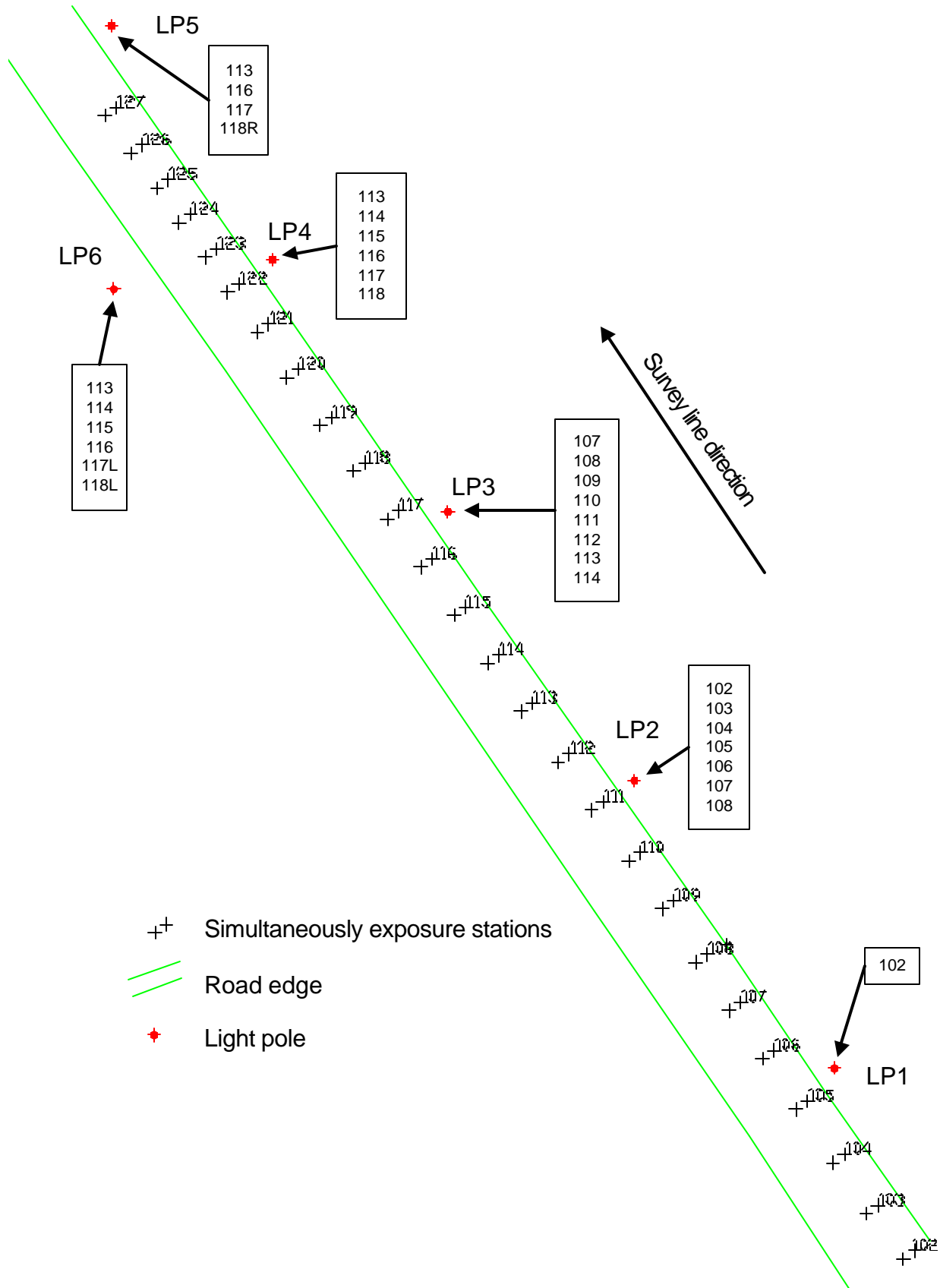


Figure 11. Object recognition from an image sequence

The locations from three intra stereo pairs nb(108L & 108R, 107L & 107R, 106L & 106R) are close to the average location. Further research should be conducted to set up criteria for selecting images for a multiple image intersection. If only two images are used for intersection, an optimization should be performed using the intersection angle as the criteria (Li et al. 1996).

Intersection Pair	X coord.	Y coord.	Z coord.	X (center)	Y (center)	Z (average)	delta X	delta Y
106L & 106R	278834.435	5047545.569	-0.058					
	278834.250	5047545.375	-0.042	278834.342	5047545.472	-0.050	0.269	-0.541
107L & 107R	278834.668	5047545.145	-0.048					
	278834.520	5047544.986	-0.036	278834.594	5047545.066	-0.042	0.017	-0.134
108L & 108R	278834.581	5047544.999	-0.018					
	278834.441	5047544.843	-0.004	278834.511	5047544.921	-0.011	0.100	0.010
106L & 107L	278834.982	5047544.372	0.031					
	278835.209	5047543.313	0.089	278835.096	5047543.842	0.060	-0.485	1.089
106R & 107R	278834.845	5047544.771	-0.060					
	278835.225	5047543.509	0.014	278835.035	5047544.140	-0.023	-0.424	0.791
107L & 108L	278833.931	5047546.947	-0.131					
	278833.802	5047546.715	-0.114	278833.867	5047546.831	-0.123	0.744	-1.900
107R & 108R	278833.530	5047547.540	-0.244					
	278833.399	5047547.310	-0.224	278833.465	5047547.425	-0.234	1.146	-2.494
106L & 107R	278835.506	5047543.302	0.055					
	278834.722	5047544.463	-0.001	278835.114	5047543.883	-0.001	-0.503	1.048
106R & 107L	278834.675	5047545.113	-0.044					
	278834.730	5047544.465	-0.005	278834.703	5047544.789	-0.025	-0.092	0.142
107L & 108R	278835.972	5047541.801	0.200					
	278835.823	5047541.713	0.208	278835.898	5047541.757	0.204	-1.286	3.174
107R & 108L	278834.164	5047546.227	-0.117					
	278834.034	5047546.015	-0.100	278834.099	5047546.121	-0.109	0.512	-1.190
		Average		278834.611	5047544.931	-0.032		
		σ		0.675	1.567	0.110		

Table 18. The coordinates of the light pole calculated by various stereo

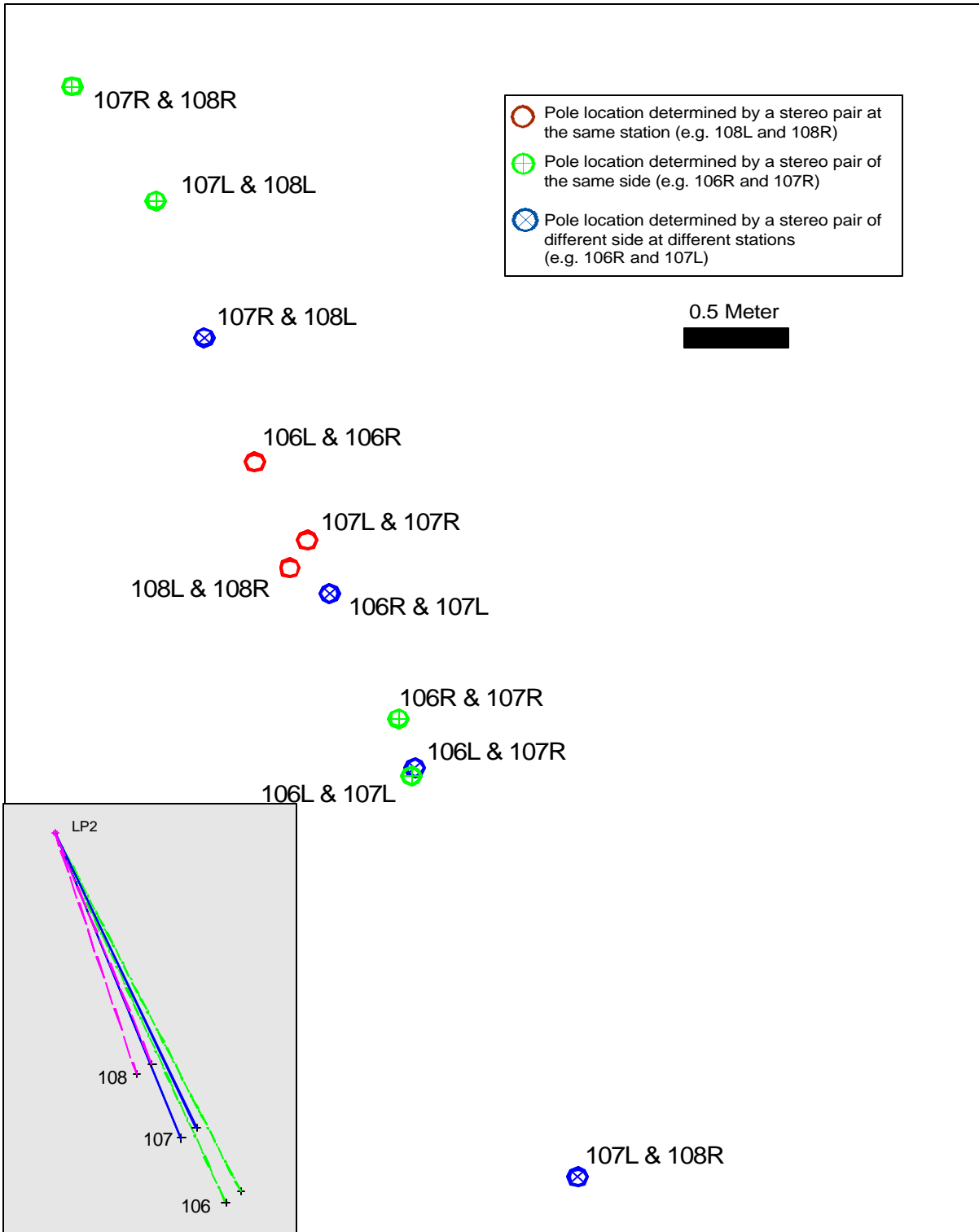


Figure 11. Distribution of the light pole locations calculated by various stereo image pair combinations provided by the neural network

5. Conclusions

In this project, an algorithm of Hopfield neural network for object recognition from mobile mapping image sequences is developed. A software system " N^2M^2 " (Neural Networks for Mobile Mapping) has been developed to implement the algorithm. The system is based on the C++ programming language in the Microsoft Windows 32bits environment. The program flow chart is depicted in Appendix A. Its source code is listed in Appendix C, and available on the tape. The major contributions of this research are

- Establishment of a Hopfield neural network for object recognition from mobile mapping image sequences using 3-D object models and 2-D image features,
- Application of the developed model to recognize and locate a specific light pole from a single image and from an image sequence, and to build a 3-D light pole database of all light poles,
- Understanding of the behavior of individual parameters of the neural network and their impact on the recognition results, and
- Development of the N^2M^2 system.

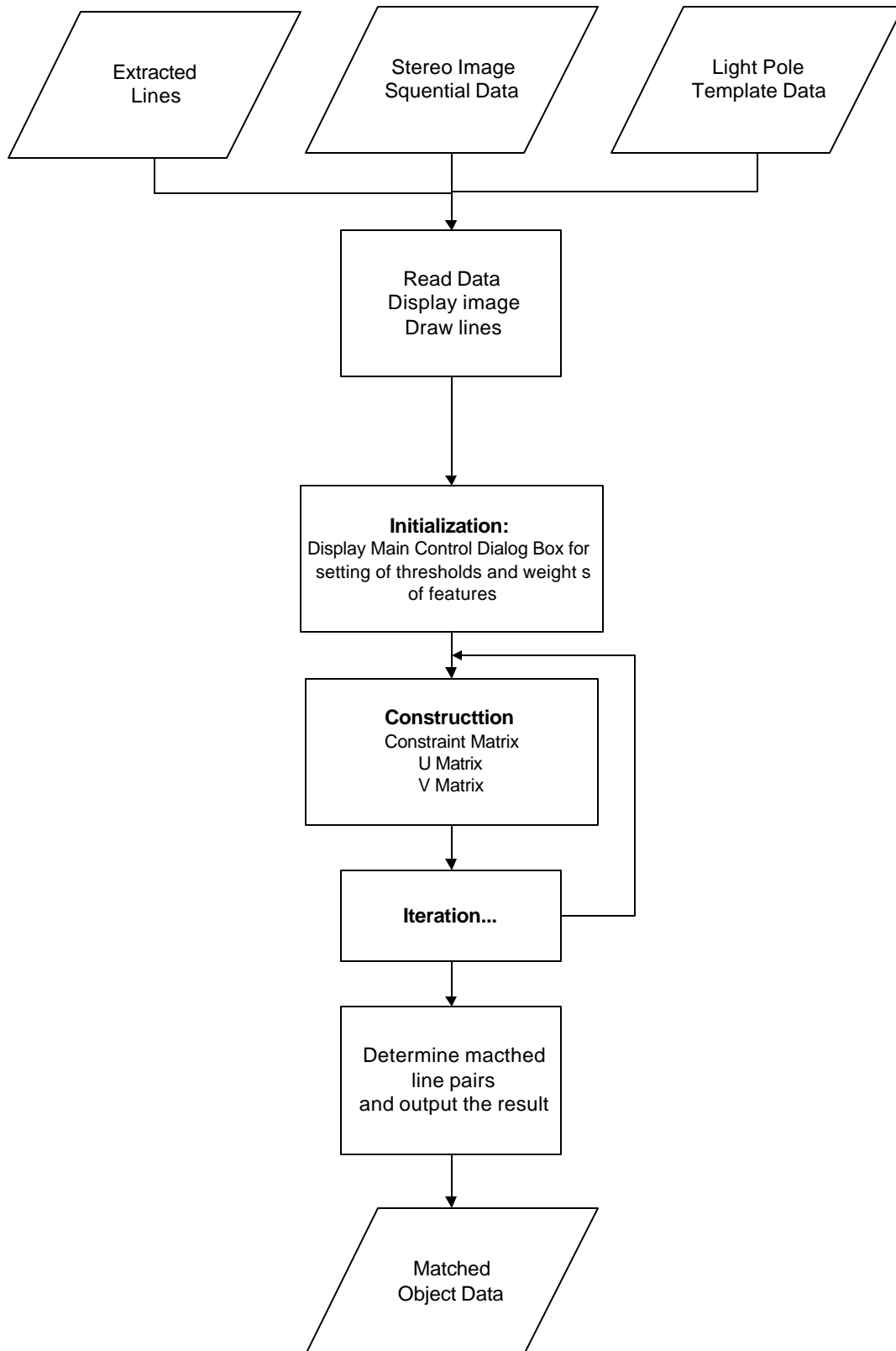
This research focuses on the automatic recognition of light poles. The measuring features of the model are the key part for characterizing objects and are object dependent. If different objects are to be recognized new measuring features should be defined and integrated in the model. Further challenge will be how to represent our knowledge about the object to be recognized in the model parameters. This will lead to a special learning process of the neural network. We believe that such research will result in a generic method for the optimal determination of thresholds and weight values in the model for different object.

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Appendix A. Program flowchart



Appendix B. Data Source

File Name : C:\MARINE\CHO
 Number of Pair : 102
 Number of Entities : 208
 Type of Entity : Line
 Point 1 : 278862.004,5047504.516,-0.667;418,250;350,215
 Point 2 : 278861.697,5047505.150,-0.084;416,231;349,198
 Code : 1020000
 Type of Entity : Line
 Point 1 : 278861.697,5047505.150,-0.084;416,231;349,198
 Point 2 : 278861.391,5047504.804,-0.075;406,232;339,198
 Code : 1020000
 Type of Entity : Line
 Point 1 : 278861.391,5047504.804,-0.075;406,232;339,198
 Point 2 : 278861.452,5047504.710,-0.732;407,251;340,217
 Code : 1020000
 Type of Entity : Line
 Point 1 : 278835.944,5047542.436,-0.049;312,211;275,178
 Point 2 : 278834.197,5047545.319,6.135;309,142;272,110
 Code : 1020000
 Type of Entity : Line
 Point 1 : 278834.075,5047544.856,6.178;306,142;269,110
 Point 2 : 278835.572,5047542.422,-0.081;309,211;272,178
 Code : 1020000
 Type of Entity : Line
 Point 1 : 278863.099,5047504.247,-0.535;442,246;372,213
 Point 2 : 278862.714,5047504.709,6.145;433,42;362,11
 Code : 1020000
 Type of Entity : Line
 Point 1 : 278862.649,5047504.553,6.168;430,42;359,11
 Point 2 : 278862.951,5047503.975,-0.547;436,246;366,213
 Code : 1020000
 Type of Entity : Line
 Point 1 : 278793.102,5047558.769,4.361;130,180;97,151
 Point 2 : 278789.374,5047557.541,7.997;107,155;73,124
 Code : 1020000
 Type of Entity : Line
 Point 1 : 278813.226,5047536.441,3.481;121,183;83,151
 Point 2 : 278778.402,5047562.349,7.604;83,162;50,133
 Code : 1020000
 Type of Entity : Line
 Point 1 : 278844.313,5047515.686,-0.251;231,227;183,196
 Point 2 : 278863.834,5047487.770,-0.919;207,339;89,313
 Code : 1020000
 Type of Entity : Line
 Point 1 : 278843.389,5047517.209,-0.290;233,227;186,195
 Point 2 : 278863.899,5047487.950,-0.947;215,340;98,312
 Code : 1020000
 Type of Entity : Line
 Point 1 : 278823.793,5047579.583,5.961;432,150;388,116
 Point 2 : 278828.813,5047576.770,5.455;483,150;436,115
 Code : 1080000
 Type of Entity : Line
 Point 1 : 278828.131,5047572.111,3.982;458,172;410,137
 Point 2 : 278823.734,5047579.228,5.953;430,151;386,115
 Code : 1080000
 Type of Entity : Line
 Point 1 : 278809.331,5047580.488,0.270;296,233;257,200
 Point 2 : 278809.532,5047579.803,6.681;292,156;252,122
 Code : 1082000
 Type of Entity : Line
 Point 1 : 278809.303,5047579.808,6.822;290,154;250,121
 Point 2 : 278809.156,5047580.166,0.165;293,235;254,201
 Code : 1082000
 Type of Entity : Line
 Point 1 : 278830.746,5047551.718,0.010;394,257;334,223
 Point 2 : 278829.962,5047548.682,0.036;354,262;292,228
 Code : 1080000

Type of Entity : Line
 Point 1 : 278829.962,5047548.682,0.036;354,262;292,228
 Point 2 : 278835.291,5047541.525,-0.120;413,285;334,251
 Code : 1080000
 Type of Entity : Line
 Point 1 : 278820.865,5047559.133,-0.185;293,253;244,220
 Point 2 : 278834.264,5047539.986,-0.193;366,293;286,259
 Code : 1080000
 Type of Entity : Line
 Point 1 : 278834.553,5047544.968,-0.015;426,270;354,238
 Point 2 : 278834.232,5047545.456,6.735;416,58;343,23
 Code : 1080000
 Type of Entity : Line
 Point 1 : 278834.309,5047544.892,6.637;413,58;340,23
 Point 2 : 278834.413,5047544.812,-0.002;421,270;349,238
 Code : 1080000
 Type of Entity : Line
 Point 1 : 278803.515,5047584.385,-0.009;345,262;284,229
 Point 2 : 278812.408,5047572.079,-0.082;442,313;345,279
 Code : 1130000
 Type of Entity : Line
 Point 1 : 278803.137,5047585.015,-0.240;344,266;284,234
 Point 2 : 278812.385,5047572.055,-0.216;441,319;344,286
 Code : 1130000
 Type of Entity : Line
 Point 1 : 278798.978,5047581.088,-0.057;228,269;167,238
 Point 2 : 278807.480,5047568.959,-0.008;215,319;120,290
 Code : 1130000
 Type of Entity : Line
 Point 1 : 278798.841,5047581.036,-0.013;225,268;164,237
 Point 2 : 278807.332,5047568.895,-0.004;209,319;114,290
 Code : 1130000
 Type of Entity : Line
 Point 1 : 278808.156,5047582.962,0.204;429,259;361,225
 Point 2 : 278808.067,5047582.777,6.728;422,70;352,36
 Code : 1130000
 Type of Entity : Line
 Point 1 : 278807.800,5047583.351,0.175;425,259;358,225
 Point 2 : 278807.730,5047583.227,6.840;418,69;348,36
 Code : 1130000
 Type of Entity : Line
 Point 1 : 278801.248,5047606.832,3.292;451,181;403,146
 Point 2 : 278799.853,5047608.099,4.590;437,162;391,128
 Code : 1130000
 Type of Entity : Line
 Point 1 : 278802.051,5047605.068,3.396;454,178;405,144
 Point 2 : 278799.882,5047608.260,4.846;438,158;392,124
 Code : 1130000
 Type of Entity : Line
 Point 1 : 278786.310,5047613.079,5.825;316,159;275,126
 Point 2 : 278784.302,5047616.635,-0.599;318,238;279,205
 Code : 1130000
 Type of Entity : Line
 Point 1 : 278784.582,5047615.599,5.958;313,159;273,126
 Point 2 : 278782.114,5047619.715,-0.694;314,238;276,204
 Code : 1130000
 Type of Entity : Line
 Point 1 : 278805.387,5047585.497,0.578;390,245;329,211
 Point 2 : 278804.795,5047586.964,-0.121;391,260;332,226
 Code : 1130000
 Type of Entity : Line
 Point 1 : 278805.062,5047585.088,0.551;380,246;319,213
 Point 2 : 278805.143,5047584.972,-0.002;381,261;320,227
 Code : 1130000
 Type of Entity : Line
 Point 1 : 278767.878,5047638.701,4.884;290,183;256,150
 Point 2 : 278761.721,5047648.713,-1.530;291,234;259,201

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Code : 1131000
Type of Entity : Line
Point 1 : 278767.514,5047638.761,5.079;288,181;254,148
Point 2 : 278761.379,5047648.352,-1.503;288,234;256,201
Code : 1132000
Type of Entity : Line
Point 1 : 278812.502,5047561.813,-0.019;189,428;16,401
Point 2 : 278808.097,5047568.073,-0.008;213,327;113,298
Code : 1130000
Type of Entity : Line
Point 1 : 278807.952,5047568.021,0.004;207,326;106,297
Point 2 : 278812.303,5047561.843,-0.047;179,427;8,401
Code : 1130000
Type of Entity : Line
Point 1 : 278761.086,5047619.774,1.183;167,222;132,191
Point 2 : 278772.008,5047604.035,1.359;144,224;104,194
Code : 1130000
Type of Entity : Line
Point 1 : 278748.351,5047634.092,-0.390;167,233;135,201
Point 2 : 278769.669,5047605.888,0.548;140,234;100,203
Code : 1130000
Type of Entity : Line
Point 1 : 278780.338,5047617.411,-0.963;289,242;251,210
Point 2 : 278803.807,5047583.588,-0.097;343,266;281,233
Code : 1130000
Type of Entity : Line
Point 1 : 278801.868,5047607.478,3.032;461,185;413,150
Point 2 : 278802.447,5047605.509,2.025;461,201;412,166
Code : 1130000
Type of Entity : Line
Point 1 : 278802.447,5047605.509,2.025;461,201;412,166
Point 2 : 278803.159,5047606.743,2.022;476,200;427,165
Code : 1130000
Type of Entity : Line
Point 1 : 278803.159,5047606.743,2.022;476,200;427,165
Point 2 : 278802.446,5047608.980,3.086;475,183;427,148
Code : 1130000
Type of Entity : Line
Point 1 : 278802.446,5047608.980,3.086;475,183;427,148
Point 2 : 278801.772,5047607.535,3.006;460,185;412,150
Code : 1130000
Type of Entity : Line
Point 1 : 278805.103,5047602.439,3.282;487,177;435,142
Point 2 : 278801.432,5047606.987,3.339;454,180;406,145
Code : 1130000
Type of Entity : Line
Point 1 : 278791.911,5047618.358,2.599;393,196;353,162
Point 2 : 278791.577,5047618.472,3.496;390,185;349,151
Code : 1130000
Type of Entity : Line
Point 1 : 278791.577,5047618.472,3.496;390,185;349,151
Point 2 : 278789.652,5047627.749,3.678;408,184;368,149
Code : 1130000
Type of Entity : Line
Point 1 : 278789.652,5047627.749,3.678;408,184;368,149
Point 2 : 278792.130,5047626.963,5.943;426,157;387,122
Code : 1130000
Type of Entity : Line
Point 1 : 278792.130,5047626.963,5.943;426,157;387,122
Point 2 : 278787.526,5047633.111,7.393;407,146;368,112
Code : 1130000
Type of Entity : Line
Point 1 : 278787.526,5047633.111,7.393;407,146;368,112
Point 2 : 278787.050,5047622.492,2.946;366,194;327,160
Code : 1130000
Type of Entity : Line
Point 1 : 278797.109,5047576.718,1.497;133,236;67,207
Point 2 : 278795.889,5047576.420,1.555;109,236;42,207
Code : 1130000
Type of Entity : Line
Point 1 : 278795.889,5047576.420,1.555;109,236;42,207
Point 2 : 278796.573,5047574.966,1.472;94,240;24,211
Code : 1130000
Type of Entity : Line
Point 1 : 278798.514,5047574.924,1.395;128,242;56,212
Point 2 : 278796.641,5047577.196,1.460;133,237;68,207
Code : 1130000
Type of Entity : Line
Point 1 : 278796.641,5047577.196,1.460;133,237;68,207
Point 2 : 278797.625,5047576.614,0.632;141,261;75,231
Code : 1130000
Type of Entity : Line
Point 1 : 278797.625,5047576.614,0.632;141,261;75,231
Point 2 : 278798.460,5047574.558,0.133;122,281;50,252
Code : 1130000
Type of Entity : Line
Point 1 : 278798.460,5047574.558,0.133;122,281;50,252
Point 2 : 278798.026,5047574.929,0.073;121,281;50,252
Code : 1130000
Type of Entity : Line
Point 1 : 278798.026,5047574.929,0.073;121,281;50,252
Point 2 : 278796.635,5047574.061,0.018;81,285;10,256
Code : 1130000
Type of Entity : Line
Point 1 : 278796.635,5047574.061,0.018;81,285;10,256
Point 2 : 278796.529,5047574.131,0.427;80,272;9,244
Code : 1130000
Type of Entity : Line
Point 1 : 278796.529,5047574.131,0.427;80,272;9,244
Point 2 : 278796.970,5047573.794,0.478;80,272;9,244
Code : 1130000
Type of Entity : Line
Point 1 : 278796.970,5047573.794,0.478;80,272;9,244
Point 2 : 278796.599,5047574.940,1.423;94,241;24,213
Code : 1130000
Type of Entity : Line
Point 1 : 278796.599,5047574.940,1.423;94,241;24,213
Point 2 : 278798.500,5047574.880,1.416;127,241;55,212
Code : 1130000
Type of Entity : Line
Point 1 : 278798.500,5047574.880,1.416;127,241;55,212
Point 2 : 278798.319,5047574.608,0.454;120,271;49,242
Code : 1130000
Type of Entity : Line
Point 1 : 278798.319,5047574.608,0.454;120,271;49,242
Point 2 : 278796.616,5047574.100,0.399;80,273;10,245
Code : 1130000
Type of Entity : Line
Point 1 : 278796.616,5047574.100,0.399;80,273;10,245
Point 2 : 278798.468,5047593.777,-0.043;340,248;289,215
Code : 1130000
Type of Entity : Line
Point 1 : 278798.468,5047593.777,-0.043;340,248;289,215
Point 2 : 278807.006,5047581.509,0.171;389,264;322,230
Code : 1130000
Type of Entity : Line
Point 1 : 278807.006,5047581.509,0.171;389,264;322,230
Point 2 : 278811.508,5047576.076,-0.066;458,291;372,257
Code : 1130000
Type of Entity : Line
Point 1 : 278811.508,5047576.076,-0.066;458,291;372,257
Point 2 : 278811.749,5047578.407,-0.152;488,285;407,250
Code : 1130000
Type of Entity : Line
Point 1 : 278811.749,5047578.407,-0.152;488,285;407,250
Point 2 : 278759.708,5047615.795,7.298;135,163;97,131
Code : 1130000
Type of Entity : Line
Point 1 : 278759.708,5047615.795,7.298;135,163;97,131
Point 2 : 278762.223,5047613.030,2.908;135,207;97,176
Code : 1130000
Type of Entity : Line
Point 1 : 278762.223,5047613.030,2.908;135,207;97,176
Point 2 : 278759.279,5047615.912,7.524;133,161;95,130
Code : 1130000
Type of Entity : Line
Point 1 : 278759.279,5047615.912,7.524;133,161;95,130
Point 2 : 278761.709,5047613.076,3.021;132,206;94,175
Code : 1130000
Type of Entity : Line
Point 1 : 278761.709,5047613.076,3.021;132,206;94,175
Point 2 : 278775.918,5047627.393,1.209;316,210;273,177
Code : 1160000
Type of Entity : Line
Point 1 : 278775.918,5047627.393,1.209;316,210;273,177
Point 2 : 278777.582,5047624.523,-0.752;318,240;274,208
Code : 1160000
Type of Entity : Line
Point 1 : 278777.582,5047624.523,-0.752;318,240;274,208
Point 2 : 278760.972,5047650.311,5.109;297,167;261,135
Code : 1160000
Type of Entity : Line
Point 1 : 278760.972,5047650.311,5.109;297,167;261,135
Point 2 : 278762.718,5047647.560,-1.366;300,232;264,199

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Code : 1160000
 Type of Entity : Line
 Point 1 : 278760.745,5047650.211,5.223;295,166;259,134
 Point 2 : 278762.451,5047647.297,-1.347;297,232;261,199
 Code : 1160000
 Del-Type of Entity : Line
 Point 1 : 278782.983,5047619.351,-0.615;351,244;303,210
 Point 2 : 278783.536,5047618.153,-5.853;348,129;298,95
 Code : 1160000
 Type of Entity : Line
 Point 1 : 278783.380,5047618.017,5.888;345,128;295,95
 Point 2 : 278783.578,5047617.647,-0.524;348,244;299,211
 Code : 1160000
 Type of Entity : Line
 Point 1 : 278756.104,5047618.797,6.795;76,145;31,113
 Point 2 : 278757.667,5047617.169,-0.987;79,251;35,222
 Code : 1160000
 Type of Entity : Line
 Point 1 : 278758.532,5047616.933,6.513;79,145;33,115
 Point 2 : 278758.123,5047617.209,-0.990;83,251;39,222
 Code : 1160000
 Type of Entity : Line
 Point 1 : 278784.295,5047602.358,-0.465;224,269;164,238
 Point 2 : 278798.054,5047582.751,-0.101;191,420;25,395
 Code : 1160000
 Type of Entity : Line
 Point 1 : 278784.637,5047601.655,-0.334;221,267;160,237
 Point 2 : 278797.974,5047582.655,-0.090;182,421;15,395
 Code : 1160000
 Type of Entity : Line
 Point 1 : 278786.913,5047608.506,-0.795;330,264;274,232
 Point 2 : 278796.256,5047595.304,-0.433;405,302;320,269
 Code : 1160000
 Type of Entity : Line
 Point 1 : 278779.956,5047618.665,-0.983;342,263;281,230
 Point 2 : 278788.417,5047606.911,-0.788;435,315;340,282
 Code : 1180000
 Type of Entity : Line
 Point 1 : 278774.106,5047616.784,-0.760;220,259;161,227
 Point 2 : 278782.841,5047604.191,-0.583;205,309;114,280
 Code : 1180000
 Type of Entity : Line
 Point 1 : 278774.814,5047616.155,-0.728;224,259;164,229
 Point 2 : 278783.502,5047603.687,-0.487;213,310;119,280
 Code : 1180000
 Type of Entity : Line
 Point 1 : 278783.045,5047619.113,6.005;406,74;340,39
 Point 2 : 278782.909,5047619.730,-0.669;410,253;347,221
 Code : 1180000
 Type of Entity : Line
 Point 1 : 278776.958,5047625.689,1.217;348,201;294,169
 Point 2 : 278777.247,5047625.237,-0.877;350,246;296,213
 Code : 1180000
 Type of Entity : Line
 Point 1 : 278782.939,5047619.027,5.992;403,74;337,40
 Point 2 : 278782.759,5047619.615,-0.679;406,254;343,221
 Code : 1180000

 Type of Entity : Line
 Point 1 : 278790.329,5047554.158,6.325;87,172;52,144
 Point 2 : 278782.861,5047563.017,8.544;96,160;62,130
 Code : 1030000
 Type of Entity : Line
 Point 1 : 278782.861,5047563.017,8.544;96,160;62,130
 Point 2 : 278791.552,5047559.890,4.296;122,189;88,159
 Code : 1030000
 Type of Entity : Line
 Point 1 : 278835.589,5047542.427,6.477;318,138;278,106
 Point 2 : 278835.710,5047542.340,0.055;321,218;282,187

Code : 1030000
 Type of Entity : Line
 Point 1 : 278835.470,5047542.044,6.433;315,138;275,106
 Point 2 : 278837.272,5047539.001,0.291;318,218;279,187
 Code : 1030000
 Type of Entity : Line
 Point 1 : 278862.042,5047504.202,-0.656;495,278;406,244
 Point 2 : 278861.835,5047504.836,-0.059;493,250;406,219
 Code : 1030000
 Type of Entity : Line
 Point 1 : 278861.835,5047504.836,-0.059;493,250;406,219
 Point 2 : 278862.338,5047503.198,-0.293;492,254;407,245
 Code : 1030000
 Type of Entity : Line
 Point 1 : 278862.338,5047503.198,-0.293;492,254;407,245
 Point 2 : 278861.371,5047504.800,-0.127;477,254;391,221
 Code : 1030000
 Type of Entity : Line
 Point 1 : 278861.371,5047504.800,-0.127;477,254;391,221
 Point 2 : 278861.618,5047504.086,-0.722;479,280;391,248
 Code : 1030000
 Type of Entity : Line
 Point 1 : 278859.130,5047507.335,-0.799;434,271;358,238
 Point 2 : 278862.448,5047503.036,-0.961;499,296;406,263
 Code : 1030000
 Type of Entity : Line
 Point 1 : 278862.448,5047503.036,-0.961;499,296;406,263
 Point 2 : 278861.629,5047501.110,-0.897;446,303;350,269
 Code : 1030000
 Type of Entity : Line
 Point 1 : 278843.097,5047517.692,-0.361;218,260;158,230
 Point 2 : 278857.290,5047497.524,-0.825;190,435;14,410
 Code : 1040000
 Type of Entity : Line
 Point 1 : 278844.351,5047515.820,-0.232;216,260;153,230
 Point 2 : 278857.152,5047497.470,-0.835;179,436;3,411
 Code : 1040000
 Type of Entity : Line
 Point 1 : 278789.568,5047555.214,6.565;60,175;23,146
 Point 2 : 278790.028,5047556.640,8.122;70,162;33,131
 Code : 1040000
 Type of Entity : Line
 Point 1 : 278790.028,5047556.640,8.122;70,162;33,131
 Point 2 : 278789.105,5047562.294,4.345;97,195;62,166
 Code : 1040000
 Type of Entity : Line
 Point 1 : 278834.649,5047544.659,6.616;317,138;274,106
 Point 2 : 278834.570,5047544.921,-0.056;320,232;278,198
 Code : 1040000
 Type of Entity : Line
 Point 1 : 278834.379,5047544.602,6.600;314,138;271,106
 Point 2 : 278836.798,5047540.291,0.048;317,232;275,198
 Code : 1040000
 Type of Entity : Line
 Point 1 : 278851.081,5047524.408,-0.357;424,250;364,215
 Point 2 : 278849.829,5047520.611,-0.290;370,254;308,220
 Code : 1040000
 Type of Entity : Line
 Point 1 : 278849.829,5047520.611,-0.290;370,254;308,220
 Point 2 : 278854.922,5047513.713,-0.561;428,277;350,244
 Code : 1040000
 Type of Entity : Line
 Point 1 : 278847.869,5047520.606,-0.476;371,278;295,246
 Point 2 : 278842.726,5047518.299,-0.334;214,278;140,248
 Code : 1050000
 Type of Entity : Line
 Point 1 : 278842.987,5047517.946,-0.314;214,279;139,248
 Point 2 : 278850.911,5047506.490,-0.626;189,391;39,364
 Code : 1050000
 Type of Entity : Line

Point 1 : 278842.520,5047518.208,-0.357;208,280;134,248
 Point 2 : 278850.875,5047506.316,-0.616;180,393;28,366
 Code : 1050000
 Type of Entity : Line
 Point 1 : 278834.331,5047545.112,6.517;331,129;285,95
 Point 2 : 278834.561,5047544.870,-0.099;336,235;290,203
 Code : 1050000
 Type of Entity : Line
 Point 1 : 278834.162,5047544.947,6.492;328,129;282,95
 Point 2 : 278835.241,5047543.002,-0.026;333,235;287,203
 Code : 1050000
 Type of Entity : Line
 Point 1 : 278793.595,5047558.160,4.243;83,193;45,163
 Point 2 : 278785.754,5047560.568,8.431;53,157;15,127
 Code : 1050000
 Type of Entity : Line
 Point 1 : 278785.754,5047560.568,8.431;53,157;15,127
 Point 2 : 278783.990,5047559.827,6.808;40,173;2,143
 Code : 1050000
 Type of Entity : Line
 Point 1 : 278848.064,5047520.239,-0.441;372,278;295,246
 Point 2 : 278852.804,5047513.724,-0.689;454,326;346,292
 Code : 1050000
 Type of Entity : Line
 Point 1 : 278852.804,5047513.724,-0.689;454,326;346,292
 Point 2 : 278852.751,5047513.919,-0.540;454,316;347,283
 Code : 1050000
 Type of Entity : Line
 Point 1 : 278830.087,5047536.195,-0.138;219,260;164,228
 Point 2 : 278840.986,5047520.784,-0.259;207,306;117,276
 Code : 1060000
 Type of Entity : Line
 Point 1 : 278825.690,5047573.954,5.562;396,163;356,129
 Point 2 : 278829.544,5047568.829,3.883;415,179;373,145
 Code : 1060000
 Type of Entity : Line
 Point 1 : 278834.810,5047544.369,6.626;355,112;303,81
 Point 2 : 278834.389,5047545.520,-0.054;361,244;310,212
 Code : 1060000
 Type of Entity : Line
 Point 1 : 278834.549,5047544.487,6.665;351,112;299,81
 Point 2 : 278834.827,5047544.132,0.014;357,244;306,212
 Code : 1060000
 Type of Entity : Line
 Point 1 : 278830.253,5047536.250,-0.168;222,260;167,229
 Point 2 : 278840.957,5047521.056,-0.293;212,306;123,276
 Code : 1060000
 Type of Entity : Line
 Point 1 : 278846.634,5047525.872,-0.290;463,288;375,254
 Point 2 : 278843.173,5047530.613,-0.212;408,270;336,236
 Code : 1060000
 Type of Entity : Line
 Point 1 : 278846.844,5047525.269,-0.253;464,288;374,256
 Point 2 : 278845.776,5047524.112,-0.294;413,295;323,262
 Code : 1060000
 Type of Entity : Line
 Point 1 : 278845.776,5047524.112,-0.294;413,295;323,262
 Point 2 : 278847.749,5047521.486,-0.408;455,316;350,284
 Code : 1060000
 Type of Entity : Line
 Point 1 : 278812.306,5047575.425,6.075;292,170;253,137
 Point 2 : 278809.738,5047579.935,0.223;294,236;257,204
 Code : 1071000
 Type of Entity : Line
 Point 1 : 278807.779,5047582.479,6.625;288,169;251,137
 Point 2 : 278809.492,5047579.673,0.149;291,237;254,205
 Code : 1072000
 Type of Entity : Line
 Point 1 : 278826.182,5047572.750,5.452;411,165;368,129
 Point 2 : 278826.358,5047577.558,4.241;431,181;389,147

Code : 1070000
 Type of Entity : Line
 Point 1 : 278834.668,5047544.684,6.518;377,101;317,66
 Point 2 : 278834.571,5047545.120,-0.024;385,260;326,228
 Code : 1070000
 Type of Entity : Line
 Point 1 : 278834.169,5047545.373,6.642;374,101;314,66
 Point 2 : 278834.822,5047544.130,0.017;381,260;322,228
 Code : 1070000
 Type of Entity : Line
 Point 1 : 278837.336,5047538.238,-0.007;382,271;313,240
 Point 2 : 278842.504,5047531.347,-0.155;464,301;371,268
 Code : 1070000
 Type of Entity : Line
 Point 1 : 278830.612,5047535.755,-0.100;211,280;145,250
 Point 2 : 278840.819,5047521.164,-0.311;184,389;43,362
 Code : 1070000
 Type of Entity : Line
 Point 1 : 278830.068,5047536.194,-0.138;207,280;142,250
 Point 2 : 278840.731,5047521.036,-0.317;175,391;33,364
 Code : 1070000
 Type of Entity : Line
 Point 1 : 278826.936,5047551.170,-0.232;346,276;276,244
 Point 2 : 278833.924,5047541.488,-0.368;451,337;339,306
 Code : 1090000
 Type of Entity : Line
 Point 1 : 278822.348,5047560.477,-0.028;342,250;286,220
 Point 2 : 278827.491,5047553.241,-0.107;380,267;312,234
 Code : 1090000
 Type of Entity : Line
 Point 1 : 278816.282,5047556.732,0.097;211,255;155,225
 Point 2 : 278829.323,5047537.963,-0.180;181,346;66,317
 Code : 1090000
 Type of Entity : Line
 Point 1 : 278816.639,5047555.890,0.135;207,256;150,225
 Point 2 : 278829.156,5047537.902,-0.177;173,346;58,317
 Code : 1090000
 Type of Entity : Line
 Point 1 : 278808.469,5047582.397,6.815;305,141;263,110
 Point 2 : 278809.835,5047580.079,0.235;309,230;267,199
 Code : 1091000
 Type of Entity : Line
 Point 1 : 278809.456,5047580.177,6.575;303,143;260,110
 Point 2 : 278809.431,5047580.250,0.165;306,232;264,199
 Code : 1092000
 Type of Entity : Line
 Point 1 : 278820.700,5047559.870,-0.167;340,271;274,237
 Point 2 : 278815.341,5047557.942,-0.034;212,270;148,241
 Code : 1100000
 Type of Entity : Line
 Point 1 : 278814.596,5047571.212,0.097;332,245;280,212
 Point 2 : 278819.138,5047565.422,-0.170;361,259;302,225
 Code : 1100000
 Type of Entity : Line
 Point 1 : 278808.842,5047581.624,6.803;323,132;277,97
 Point 2 : 278808.968,5047581.655,0.230;328,234;283,201
 Code : 1100000
 Type of Entity : Line
 Point 1 : 278808.597,5047581.588,6.856;320,131;274,97
 Point 2 : 278808.853,5047581.372,0.216;325,234;280,202
 Code : 1100000
 Type of Entity : Line
 Point 1 : 278814.763,5047575.686,1.677;364,212;314,176
 Point 2 : 278814.782,5047575.536,0.598;364,231;314,197
 Code : 1100000
 Type of Entity : Line
 Point 1 : 278765.547,5047589.868,6.017;40,180;1,152
 Point 2 : 278772.621,5047586.637,5.621;59,180;19,152
 Code : 1100000
 Type of Entity : Line

Point 1 : 278772.621,5047586.637,5.621;59,180;19,152
 Point 2 : 278775.953,5047583.424,3.193;58,207;17,177
 Code : 1100000
 Type of Entity : Line
 Point 1 : 278821.277,5047567.981,0.414;420,239;361,207
 Point 2 : 278821.488,5047567.362,1.546;419,213;359,180
 Code : 1100000
 Type of Entity : Line
 Point 1 : 278821.488,5047567.362,1.546;419,213;359,180
 Point 2 : 278821.123,5047566.959,1.637;409,212;349,178
 Code : 1100000
 Type of Entity : Line
 Point 1 : 278821.123,5047566.959,1.637;409,212;349,178
 Point 2 : 278821.517,5047565.944,0.591;410,239;349,204
 Code : 1100000
 Type of Entity : Line
 Point 1 : 278822.718,5047559.487,0.064;381,265;312,231
 Point 2 : 278827.105,5047554.267,-0.290;450,295;364,263
 Code : 1100000
 Type of Entity : Line
 Point 1 : 278820.768,5047559.918,-0.224;342,272;276,239
 Point 2 : 278826.528,5047551.670,-0.207;399,304;308,272
 Code : 1100000
 Type of Entity : Line
 Point 1 : 278815.277,5047557.758,-0.066;210,296;127,265
 Point 2 : 278821.313,5047549.082,-0.168;178,392;31,364
 Code : 1110000
 Type of Entity : Line
 Point 1 : 278815.361,5047557.452,-0.002;206,294;122,265
 Point 2 : 278821.158,5047549.019,-0.193;168,393;21,367
 Code : 1110000
 Type of Entity : Line
 Point 1 : 278814.609,5047576.739,0.633;412,233;355,197
 Point 2 : 278814.070,5047577.918,1.552;410,211;354,177
 Code : 1110000
 Type of Entity : Line
 Point 1 : 278814.070,5047577.918,1.552;410,211;354,177
 Point 2 : 278813.297,5047578.392,1.566;400,210;345,178
 Code : 1110000
 Type of Entity : Line
 Point 1 : 278813.297,5047578.392,1.566;400,210;345,178
 Point 2 : 278813.789,5047577.218,0.490;401,235;345,201
 Code : 1110000
 Type of Entity : Line
 Point 1 : 278807.942,5047583.281,0.081;353,238;304,205
 Point 2 : 278808.371,5047582.139,6.753;348,116;297,81
 Code : 1110000
 Type of Entity : Line
 Point 1 : 278808.196,5047582.049,6.739;345,116;294,82
 Point 2 : 278808.442,5047581.647,0.114;349,239;299,206
 Code : 1110000
 Type of Entity : Line
 Point 1 : 278808.442,5047581.647,0.114;349,239;299,206
 Point 2 : 278814.736,5047570.423,0.115;365,254;303,220
 Code : 1110000
 Type of Entity : Line
 Point 1 : 278814.736,5047570.423,0.115;365,254;303,220
 Point 2 : 278819.474,5047564.260,-0.078;415,275;339,241
 Code : 1110000
 Type of Entity : Line
 Point 1 : 278818.008,5047563.869,-0.306;372,283;298,250
 Point 2 : 278820.276,5047560.400,-0.255;394,296;309,264
 Code : 1110000
 Type of Entity : Line
 Point 1 : 278805.867,5047571.473,-0.004;227,274;162,243
 Point 2 : 278813.454,5047560.649,-0.003;212,326;110,297
 Code : 1120000
 Type of Entity : Line
 Point 1 : 278806.421,5047570.379,0.015;222,277;155,245
 Point 2 : 278813.170,5047560.735,-0.017;205,326;104,296

Code : 1120000
 Type of Entity : Line
 Point 1 : 278803.111,5047600.667,4.555;414,165;368,131
 Point 2 : 278801.922,5047605.479,3.333;422,184;378,151
 Code : 1120000
 Type of Entity : Line
 Point 1 : 278807.863,5047583.465,7.061;379,95;322,63
 Point 2 : 278808.261,5047582.990,0.103;386,249;330,217
 Code : 1120000
 Type of Entity : Line
 Point 1 : 278808.143,5047582.446,7.097;376,92;318,59
 Point 2 : 278808.499,5047581.919,0.194;382,249;325,216
 Code : 1120000
 Type of Entity : Line
 Point 1 : 278814.098,5047578.572,0.498;469,246;403,211
 Point 2 : 278814.257,5047578.015,1.536;468,218;401,183
 Code : 1120000
 Type of Entity : Line
 Point 1 : 278814.257,5047578.015,1.536;468,218;401,183
 Point 2 : 278813.869,5047577.485,1.569;455,218;388,183
 Code : 1120000
 Type of Entity : Line
 Point 1 : 278813.869,5047577.485,1.569;455,218;388,183
 Point 2 : 278813.929,5047577.338,0.524;456,248;389,212
 Code : 1120000
 Type of Entity : Line
 Point 1 : 278804.358,5047583.413,-0.316;327,258;274,226
 Point 2 : 278810.424,5047574.769,-0.210;356,273;291,240
 Code : 1120000
 Type of Entity : Line
 Point 1 : 278812.889,5047571.111,-0.112;373,281;300,248
 Point 2 : 278818.354,5047563.599,-0.241;455,329;350,296
 Code : 1120000
 Type of Entity : Line
 Point 1 : 278787.422,5047633.947,7.569;423,136;383,100
 Point 2 : 278788.110,5047634.994,6.106;433,152;393,117
 Code : 1140000
 Type of Entity : Line
 Point 1 : 278788.110,5047634.994,6.106;433,152;393,117
 Point 2 : 278785.641,5047635.556,4.042;413,177;374,142
 Code : 1140000
 Type of Entity : Line
 Point 1 : 278791.685,5047591.636,-0.218;226,262;170,231
 Point 2 : 278798.172,5047582.431,-0.072;221,283;149,253
 Code : 1140000
 Type of Entity : Line
 Point 1 : 278791.525,5047591.580,-0.192;223,262;167,230
 Point 2 : 278798.314,5047581.992,-0.023;217,283;144,253
 Code : 1140000
 Type of Entity : Line
 Point 1 : 278755.992,5047619.538,7.270;117,156;78,125
 Point 2 : 278759.210,5047616.242,1.255;119,221;80,189
 Code : 1140000
 Type of Entity : Line
 Point 1 : 278761.553,5047613.673,6.792;115,156;74,125
 Point 2 : 278761.468,5047613.540,1.278;116,221;76,190
 Code : 1140000
 Type of Entity : Line
 Point 1 : 278783.577,5047618.044,6.142;321,149;279,116
 Point 2 : 278783.487,5047618.195,-0.650;323,239;282,206
 Code : 1140000
 Type of Entity : Line
 Point 1 : 278783.440,5047617.726,6.180;318,148;276,116
 Point 2 : 278784.648,5047615.457,-0.498;320,239;278,206
 Code : 1140000
 Type of Entity : Line
 Point 1 : 278804.907,5047586.833,0.518;436,255;362,222
 Point 2 : 278804.781,5047585.938,0.525;424,256;349,225
 Code : 1140000
 Type of Entity : Line

Point 1 : 278804.781,5047585.938,0.525;424,256;349,225
 Point 2 : 278804.983,5047585.536,0.015;426,276;350,242
 Code : 1140000
 Type of Entity : Line
 Point 1 : 278795.913,5047595.768,-0.510;331,262;276,230
 Point 2 : 278803.327,5047584.892,-0.190;375,283;301,251
 Code : 1140000
 Type of Entity : Line
 Point 1 : 278798.390,5047582.007,-0.129;219,287;146,256
 Point 2 : 278807.353,5047569.367,-0.004;193,410;33,383
 Code : 1140000
 Type of Entity : Line
 Point 1 : 278798.830,5047581.242,-0.050;216,287;141,257
 Point 2 : 278807.244,5047569.253,-0.004;182,411;21,385
 Code : 1140000
 Type of Entity : Line
 Point 1 : 278807.979,5047583.533,6.208;496,34;408,2
 Point 2 : 278808.032,5047583.848,0.150;504,280;418,244
 Code : 1140000
 Type of Entity : Line
 Point 1 : 278807.929,5047583.157,6.187;491,34;402,0
 Point 2 : 278807.848,5047583.644,0.129;496,281;410,246
 Code : 1140000
 Type of Entity : Line
 Point 1 : 278785.331,5047638.190,4.503;439,168;398,132
 Point 2 : 278787.387,5047637.808,6.399;458,142;416,108
 Code : 1150000
 Type of Entity : Line
 Point 1 : 278787.387,5047637.808,6.399;458,142;416,108
 Point 2 : 278786.479,5047636.705,7.644;445,127;403,93
 Code : 1150000
 Type of Entity : Line
 Point 1 : 278786.479,5047636.705,7.644;445,127;403,93
 Point 2 : 278791.164,5047630.350,5.994;475,141;430,105
 Code : 1150000
 Type of Entity : Line
 Point 1 : 278791.164,5047630.350,5.994;475,141;430,105
 Point 2 : 278786.988,5047635.558,3.818;447,175;405,139
 Code : 1150000
 Type of Entity : Line
 Point 1 : 278758.873,5047616.615,-0.861;104,248;63,219
 Point 2 : 278758.037,5047617.362,6.146;100,161;58,132
 Code : 1150000
 Type of Entity : Line
 Point 1 : 278757.341,5047617.616,6.149;97,162;55,132
 Point 2 : 278760.547,5047614.493,-0.752;100,249;58,219
 Code : 1150000
 Type of Entity : Line
 Point 1 : 278791.137,5047592.467,-0.281;222,278;157,248
 Point 2 : 278798.140,5047582.533,-0.080;212,322;115,292
 Code : 1150000
 Type of Entity : Line
 Point 1 : 278791.390,5047591.913,-0.221;219,278;153,248
 Point 2 : 278798.152,5047582.309,-0.046;207,322;109,292
 Code : 1150000
 Type of Entity : Line
 Point 1 : 278783.222,5047618.728,6.136;332,142;287,107
 Point 2 : 278783.265,5047618.735,-0.629;335,243;291,210
 Code : 1150000
 Type of Entity : Line

Point 1 : 278784.073,5047616.712,5.906;330,143;284,109
 Point 2 : 278783.024,5047618.496,-0.645;331,244;287,210
 Code : 1150000
 Type of Entity : Line
 Point 1 : 278797.372,5047593.292,-0.167;362,277;292,243
 Point 2 : 278803.183,5047585.427,-0.092;444,315;344,282
 Code : 1150000
 Type of Entity : Line
 Point 1 : 278783.426,5047603.324,-0.456;215,283;144,252
 Point 2 : 278790.187,5047593.764,-0.248;200,343;87,313
 Code : 1170000
 Type of Entity : Line
 Point 1 : 278759.054,5047653.628,5.488;302,157;265,125
 Point 2 : 278760.999,5047650.409,-1.376;305,231;268,196
 Code : 1170000
 Type of Entity : Line
 Point 1 : 278761.019,5047649.678,5.284;300,158;262,125
 Point 2 : 278760.574,5047650.455,-1.420;302,231;265,197
 Code : 1170000
 Type of Entity : Line
 Point 1 : 278784.078,5047617.021,5.808;372,107;314,73
 Point 2 : 278783.498,5047618.485,-0.513;376,248;321,214
 Code : 1170000
 Type of Entity : Line
 Point 1 : 278783.489,5047617.830,5.912;368,107;311,73
 Point 2 : 278783.309,5047618.228,-0.516;371,248;316,215
 Code : 1170000
 Type of Entity : Line
 Point 1 : 278788.826,5047605.823,-0.626;372,284;299,251
 Point 2 : 278795.301,5047596.892,-0.500;487,346;371,313
 Code : 1170000
 Type of Entity : Line
 Point 1 : 278783.301,5047603.819,-0.469;220,282;150,250
 Point 2 : 278790.331,5047593.821,-0.267;207,343;94,315
 Code : 1170000
 Type of Entity : Line
 Point 1 : 278838.701,5047548.128,8.199;479,55;417,20
 Point 2 : 278837.991,5047549.632,6.210;474,109;414,74
 Code : 1070000
 Type of Entity : Line
 Point 1 : 278839.467,5047546.610,7.838;487,56;423,21
 Point 2 : 278838.356,5047549.884,5.158;483,133;423,98
 Code : 1070000
 Type of Entity : Line
 Point 1 : 278838.356,5047549.884,5.158;483,133;423,98
 Point 2 : 278838.393,5047549.469,2.631;483,192;423,156
 Code : 1070000
 Type of Entity : Line
 Point 1 : 278838.155,5047548.369,5.068;471,133;410,99
 Point 2 : 278838.019,5047548.970,2.546;473,194;413,159
 Code : 1070000
 Type of Entity : Line
 Point 1 : 278827.334,5047566.582,3.971;467,155;410,122
 Point 2 : 278827.990,5047564.070,2.055;467,198;408,162
 Code : 1090000
 Type of Entity : Line
 Point 1 : 278827.599,5047563.970,3.889;458,155;399,122
 Point 2 : 278827.457,5047564.644,1.962;460,201;402,164
 Code : 1090000

Appendix C Results

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***** CHO_102_0.dat *****
Stereo Image File Name : C:\MARINE\CHO.fit
Number of Pair       : 102
Image Sequence       : 0
Number of Entities   : 4
1020003;-1;312,211;309,142~32;278833.6638,5047546.5245,-0.1878;278832.0524,5047549.1722,6.4489
    1021003,1,278833.6638,5047546.5245,-0.1878
    1030086,0,278826.2356,5047559.8504,-0.3537
    1031086,1,278840.0621,5047535.0211,0.1100
1020004;1;309,211;306,142~32;278833.4115,5047546.2667,-0.1697;278831.7704,5047548.9436,6.4643
    1021004,1,278833.4115,5047546.2667,-0.1697
    1030087,0,278827.3884,5047556.9579,-0.2786
    1031087,1,278838.8174,5047536.6458,0.0821
1020005;-1;442,246;433,42~12;278863.1070,5047504.2235,-0.5496;278862.7249,5047504.6827,6.1560
    1021005,1,278863.1070,5047504.2235,-0.5496
1020006;1;436,246;430,42~12;278862.9378,5047504.0117,-0.5327;278862.6330,5047504.5941,6.1590
    1021006,1,278862.9378,5047504.0117,-0.5327
=====
***** CHO_102_1.dat *****
Stereo Image File Name : C:\MARINE\CHO.fit
Number of Pair       : 102
Image Sequence       : 1
Number of Entities   : 6
1021002;-1;340,217;339,198~1;278745.8099,5047749.9403,-19.8457;278745.8099,5047749.9403,-13.0507
1021000;1;350,215;349,198~1;278734.8064,5047784.5799,-21.7981;278734.8064,5047784.5799,-15.0031
1021003;-1;275,178;272,110~32;278833.6638,5047546.5245,-0.1878;278832.0524,5047549.1722,6.4489
    1020003,0,278833.6638,5047546.5245,-0.1878
    1031086,1,278820.3410,5047569.1336,-0.6939
    1030086,0,278830.9636,5047551.0996,-0.1715
1021004;1;272,178;269,110~32;278833.4115,5047546.2667,-0.1697;278831.7704,5047548.9436,6.4643
    1020004,0,278833.4115,5047546.2667,-0.1697
    1031087,1,278822.0402,5047565.3729,-0.5887
    1030087,0,278831.1730,5047550.0211,-0.1351
1021005;-1;372,213;362,11~12;278863.1070,5047504.2235,-0.5496;278862.7249,5047504.6827,6.1560
    1020005,0,278863.1070,5047504.2235,-0.5496
1021006;1;366,213;359,11~12;278862.9378,5047504.0117,-0.5327;278862.6330,5047504.5941,6.1590
    1020006,0,278862.9378,5047504.0117,-0.5327
=====
***** CHO_103_0.dat *****
Stereo Image File Name : C:\MARINE\CHO.fit
Number of Pair       : 103
Image Sequence       : 0
Number of Entities   : 2
1030086;-1;321,218;318,138~52;278834.0761,5047545.3596,-0.0149;278834.0607,5047545.2470,6.6768
    1031086,1,278834.0761,5047545.3596,-0.0149
    1020003,0,278826.2356,5047559.8504,-0.3537
    1021003,1,278830.9636,5047551.0996,-0.1715
    1040098,0,278842.4271,5047529.8777,0.3627
    1041098,1,278829.7600,5047553.3932,-0.1949
1030087;1;318,218;315,138~52;278833.8439,5047545.1470,0.0012;278833.8246,5047545.0466,6.6897
    1031087,1,278833.8439,5047545.1470,0.0012
    1020004,0,278827.3884,5047556.9579,-0.2786
    1021004,1,278831.1730,5047550.0211,-0.1351
    1040099,0,278843.1933,5047528.0049,0.4153
    1041099,1,278828.5523,5047554.8858,-0.2206
=====
***** CHO_103_1.dat *****
Stereo Image File Name : C:\MARINE\CHO.fit
Number of Pair       : 103
Image Sequence       : 1
Number of Entities   : 2
1031086;-1;282,187;278,106~52;278834.0761,5047545.3596,-0.0149;278834.0607,5047545.2470,6.6768
    1030086,0,278834.0761,5047545.3596,-0.0149
    1021003,1,278820.3410,5047569.1336,-0.6939
    1020003,0,278840.0621,5047535.0211,0.1100
    1041098,1,278841.8706,5047531.9172,0.2583
    1040098,0,278836.6650,5047540.8946,-0.0037
1031087;1;279,187;275,106~52;278833.8439,5047545.1470,0.0012;278833.8246,5047545.0466,6.6897

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1030087,0,278833.8439,5047545.1470,0.0012
1021004,1,278822.0402,5047565.3729,-0.5887
1020004,0,278838.8174,5047536.6458,0.0821
1041099,1,278843.1799,5047529.2017,0.3369
1040099,0,278836.8722,5047539.9736,0.0292
=====
***** CHO_104_0.dat *****
Stereo Image File Name : C:\MARINE\CHO.fit
Number of Pair       : 104
Image Sequence       : 0
Number of Entities    : 2
1040098;-1;320,232;317,138~52;278834.5748,5047544.9094,-0.0915;278834.6493,5047544.6592,6.6155
1041098,1,278834.5748,5047544.9094,-0.0915
1030086,0,278842.4271,5047529.8777,0.3627
1031086,1,278836.6650,5047540.8946,-0.0037
1050105,0,278835.1656,5047543.7887,-0.0570
1051105,1,278833.5596,5047546.8717,-0.1963
1040099;1;317,232;314,138~52;278834.3798,5047544.7102,-0.0785;278834.4395,5047544.4931,6.6252
1041099,1,278834.3798,5047544.7102,-0.0785
1030087,0,278843.1933,5047528.0049,0.4153
1031087,1,278836.8722,5047539.9736,0.0292
1050106,0,278835.7148,5047542.1895,-0.0010
1051106,1,278832.2551,5047548.7652,-0.2522
=====
***** CHO_104_1.dat *****
Stereo Image File Name : C:\MARINE\CHO.fit
Number of Pair       : 104
Image Sequence       : 1
Number of Entities    : 2
1041098;-1;278,198;274,106~52;278834.5748,5047544.9094,-0.0915;278834.6493,5047544.6592,6.6155
1040098,0,278834.5748,5047544.9094,-0.0915
1031086,1,278841.8706,5047531.9172,0.2583
1030086,0,278829.7600,5047553.3932,-0.1949
1051105,1,278836.3819,5047541.6777,0.0044
1050105,0,278834.9452,5047544.2543,-0.0416
1041099;1;275,198;271,106~52;278834.3798,5047544.7102,-0.0785;278834.4395,5047544.4931,6.6252
1040099,0,278834.3798,5047544.7102,-0.0785
1031087,1,278843.1799,5047529.2017,0.3369
1030087,0,278828.5523,5047554.8858,-0.2206
1051106,1,278837.1271,5047539.8641,0.0703
1050106,0,278835.0971,5047543.4518,-0.0098
=====
***** CHO_105_0.dat *****
Stereo Image File Name : C:\MARINE\CHO.fit
Number of Pair       : 105
Image Sequence       : 0
Number of Entities    : 2
1050105;-1;336,235;331,129~52;278834.6173,5047544.9242,-0.1026;278833.4156,5047546.9576,6.6791
1051105,1,278834.6173,5047544.9242,-0.1026
1040098,0,278835.1656,5047543.7887,-0.0570
1041098,1,278834.9452,5047544.2543,-0.0416
1060113,0,278835.8480,5047542.4476,0.0693
1061113,1,278831.9698,5047550.3460,-0.2841
1050106;1;333,235;328,129~52;278834.4480,5047544.7613,-0.0914;278833.2349,5047546.7986,6.6865
1051106,1,278834.4480,5047544.7613,-0.0914
1040099,0,278835.7148,5047542.1895,-0.0010
1041099,1,278835.0971,5047543.4518,-0.0098
1060114,0,278835.3443,5047542.9851,0.0528
1061114,1,278832.3064,5047549.0930,-0.2265
=====
***** CHO_105_1.dat *****
Stereo Image File Name : C:\MARINE\CHO.fit
Number of Pair       : 105
Image Sequence       : 1
Number of Entities    : 2
1051105;-1;290,203;285,95~52;278834.6173,5047544.9242,-0.1026;278833.4156,5047546.9576,6.6791
1050105,0,278834.6173,5047544.9242,-0.1026
1041098,1,278836.3819,5047541.6777,0.0044
1040098,0,278833.5596,5047546.8717,-0.1963
1061113,1,278836.7163,5047541.0767,0.0544
1060113,0,278835.2372,5047543.7948,-0.0211

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1051106;1;287,203;282,95~52;278834.4480,5047544.7613,-0.0914;278833.2349,5047546.7986,6.6865
1050106,0,278834.4480,5047544.7613,-0.0914
1041099,1,278837.1271,5047539.8641,0.0703
1040099,0,278832.2551,5047548.7652,-0.2522
1061114,1,278836.0933,5047541.7869,0.0322
1060114,0,278834.9079,5047543.9372,-0.0207
=====
***** CHO_106_0.dat *****
Stereo Image File Name : C:\MARINE\CHO.fit
Number of Pair       : 106
Image Sequence       : 0
Number of Entities   : 2
1060113;-1;361,244;355,112~52;278834.4353,5047545.5692,-0.0583;278834.2118,5047545.8025,6.7724
1061113,1,278834.4353,5047545.5692,-0.0583
1050105,0,278835.8480,5047542.4476,0.0693
1051105,1,278835.2372,5047543.7948,-0.0211
1070122,0,278834.9821,5047544.3720,0.0313
1071122,1,278835.5058,5047543.3015,0.0548
1060114;1;357,244;351,112~52;278834.2502,5047545.3745,-0.0423;278834.0186,5047545.6257,6.7822
1061114,1,278834.2502,5047545.3745,-0.0423
1050106,0,278835.3443,5047542.9851,0.0528
1051106,1,278834.9079,5047543.9372,-0.0207
1070123,0,278835.2090,5047543.3129,0.0890
1071123,1,278834.7218,5047544.4634,-0.0013
=====
***** CHO_106_1.dat *****
Stereo Image File Name : C:\MARINE\CHO.fit
Number of Pair       : 106
Image Sequence       : 1
Number of Entities   : 2
1061113;-1;310,212;303,81~52;278834.4353,5047545.5692,-0.0583;278834.2118,5047545.8025,6.7724
1060113,0,278834.4353,5047545.5692,-0.0583
1051105,1,278836.7163,5047541.0767,0.0544
1050105,0,278831.9698,5047550.3460,-0.2841
1071122,1,278834.8453,5047544.7713,-0.0596
1070122,0,278834.6752,5047545.1132,-0.0442
1061114;1;306,212;299,81~52;278834.2502,5047545.3745,-0.0423;278834.0186,5047545.6257,6.7822
1060114,0,278834.2502,5047545.3745,-0.0423
1051106,1,278836.0933,5047541.7869,0.0322
1050106,0,278832.3064,5047549.0930,-0.2265
1071123,1,278835.2253,5047543.5088,0.0140
1070123,0,278834.7297,5047544.4646,-0.0054
=====
***** CHO_107_0.dat *****
Stereo Image File Name : C:\MARINE\CHO.fit
Number of Pair       : 107
Image Sequence       : 0
Number of Entities   : 4
1070119;-1;294,236;292,170~32;278809.7378,5047579.9346,0.2230;278812.3056,5047575.4253,6.0751
1071119,1,278809.7378,5047579.9346,0.2230
1080013,0,278805.8109,5047586.8597,0.0911
1081013,1,278811.3629,5047577.0545,0.3554
1070120;1;291,237;288,169~32;278809.4918,5047579.6725,0.1487;278807.7789,5047582.4790,6.6252
1071120,1,278809.4918,5047579.6725,0.1487
1080014,0,278808.6386,5047581.1235,0.1213
1081014,1,278810.1273,5047578.5513,0.2401
1070122;-1;385,260;377,101~52;278834.6683,5047545.1448,-0.0483;278834.3226,5047545.5210,6.6369
1071122,1,278834.6683,5047545.1448,-0.0483
1060113,0,278834.9821,5047544.3720,0.0313
1061113,1,278834.6752,5047545.1132,-0.0442
1080018,0,278833.9309,5047546.9474,-0.1310
1081018,1,278835.9718,5047541.8006,0.2004
1070123;1;381,260;374,101~52;278834.5203,5047544.9860,-0.0358;278834.2075,5047545.4095,6.6409
1071123,1,278834.5203,5047544.9860,-0.0358
1060114,0,278835.2090,5047543.3129,0.0890
1061114,1,278834.7297,5047544.4646,-0.0054
1080019,0,278833.8021,5047546.7149,-0.1145
1081019,1,278835.8229,5047541.7125,0.2081
=====
***** CHO_107_1.dat *****
Stereo Image File Name : C:\MARINE\CHO.fit

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Number of Pair      : 107
Image Sequence      : 1
Number of Entities  : 4
1071119;-1;257,204;253,137~32;278809.7378,5047579.9346,0.2230;278812.3056,5047575.4253,6.0751
    1070119,0,278809.7378,5047579.9346,0.2230
    1081013,1,278802.4519,5047592.1031,-0.0962
    1080013,0,278808.2893,5047582.3598,0.1643
1071120;1;254,205;251,137~32;278809.4918,5047579.6725,0.1487;278807.7789,5047582.4790,6.6252
    1070120,0,278809.4918,5047579.6725,0.1487
    1081014,1,278804.1718,5047588.4854,-0.0837
    1080014,0,278808.6186,5047581.1172,0.0773
1071122;-1;326,228;317,66~52;278834.6683,5047545.1448,-0.0483;278834.3226,5047545.5210,6.6369
    1070122,0,278834.6683,5047545.1448,-0.0483
    1061113,1,278834.8453,5047544.7713,-0.0596
    1060113,0,278835.5058,5047543.3015,0.0548
    1081018,1,278833.5298,5047547.5398,-0.2440
    1080018,0,278834.1636,5047546.2269,-0.1168
1071123;1;322,228;314,66~52;278834.5203,5047544.9860,-0.0358;278834.2075,5047545.4095,6.6409
    1070123,0,278834.5203,5047544.9860,-0.0358
    1061114,1,278835.2253,5047543.5088,0.0140
    1060114,0,278834.7218,5047544.4634,-0.0013
    1081019,1,278833.3992,5047547.3100,-0.2242
    1080019,0,278834.0335,5047546.0145,-0.1000
=====
***** CHO_108_0.dat *****
Stereo Image File Name : C:\MARINE\CHO.fit
Number of Pair      : 108
Image Sequence      : 0
Number of Entities  : 4
1080013;-1;296,233;292,156~52;278809.3308,5047580.4876,0.2703;278809.5318,5047579.8035,6.6814
    1081013,1,278809.3308,5047580.4876,0.2703
    1070119,0,278805.8109,5047586.8597,0.0911
    1071119,1,278808.2893,5047582.3598,0.1643
    1090131,0,278817.9141,5047565.0047,0.7668
    1091131,1,278805.0127,5047588.3456,-0.0493
1080014;1;293,235;290,154~52;278809.1557,5047580.1657,0.1645;278809.3025,5047579.8077,6.8223
    1081014,1,278809.1557,5047580.1657,0.1645
    1070120,0,278808.6386,5047581.1235,0.1213
    1071120,1,278808.6186,5047581.1172,0.0773
    1090132,0,278818.9323,5047562.7150,0.7358
    1091132,1,278802.4092,5047592.2286,-0.2654
1080018;-1;426,270;416,58~32;278834.5812,5047544.9991,-0.0175;278834.2221,5047545.4812,6.7246
    1081018,1,278834.5812,5047544.9991,-0.0175
    1070122,0,278833.9309,5047546.9474,-0.1310
    1071122,1,278834.1636,5047546.2269,-0.1168
1080019;1;421,270;413,58~32;278834.4411,5047544.8428,-0.0043;278834.1332,5047545.3971,6.7270
    1081019,1,278834.4411,5047544.8428,-0.0043
    1070123,0,278833.8021,5047546.7149,-0.1145
    1071123,1,278834.0335,5047546.0145,-0.1000
=====
***** CHO_108_1.dat *****
Stereo Image File Name : C:\MARINE\CHO.fit
Number of Pair      : 108
Image Sequence      : 1
Number of Entities  : 4
1081013;-1;257,200;252,122~52;278809.3308,5047580.4876,0.2703;278809.5318,5047579.8035,6.6814
    1080013,0,278809.3308,5047580.4876,0.2703
    1071119,1,278802.4519,5047592.1031,-0.0962
    1070119,0,278811.3629,5047577.0545,0.3554
    1091131,1,278822.5133,5047558.2047,0.9371
    1090131,0,278812.3761,5047575.3375,0.4445
1081014;1;254,201;250,121~52;278809.1557,5047580.1657,0.1645;278809.3025,5047579.8077,6.8223
    1080014,0,278809.1557,5047580.1657,0.1645
    1071120,1,278804.1718,5047588.4854,-0.0837
    1070120,0,278810.1273,5047578.5513,0.2401
    1091132,1,278822.9929,5047557.0496,0.9554
    1090132,0,278812.7177,5047574.2016,0.3866
1081018;-1;354,238;343,23~32;278834.5812,5047544.9991,-0.0175;278834.2221,5047545.4812,6.7246
    1080018,0,278834.5812,5047544.9991,-0.0175
    1071122,1,278833.5298,5047547.5398,-0.2440
    1070122,0,278835.9718,5047541.8006,0.2004

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1081019;1;349,238;340,23~32;278834.4411,5047544.8428,-0.0043;278834.1332,5047545.3971,6.7270
1080019,0,278834.4411,5047544.8428,-0.0043
1071123,1,278833.3992,5047547.3100,-0.2242
1070123,0,278835.8229,5047541.7125,0.2081
=====
***** CHO_109_0.dat *****
Stereo Image File Name : C:\MARINE\CHO.fit
Number of Pair       : 109
Image Sequence       : 0
Number of Entities   : 4
1090131;-1;309,230;305,141~52;278809.8345,5047580.0794,0.2352;278808.4688,5047582.3969,6.8150
1091131,1,278809.8345,5047580.0794,0.2352
1080013,0,278817.9141,5047565.0047,0.7668
1081013,1,278812.3761,5047575.3375,0.4445
1100135,0,278808.8029,5047581.9835,0.2321
1101135,1,278809.4769,5047580.7436,0.2728
1090132;1;306,232;303,143~52;278809.4312,5047580.2501,0.1650;278809.4564,5047580.1774,6.5746
1091132,1,278809.4312,5047580.2501,0.1650
1080014,0,278818.9323,5047562.7150,0.7358
1081014,1,278812.7177,5047574.2016,0.3866
1100136,0,278808.8968,5047581.2598,0.1912
1101136,1,278807.8669,5047583.1188,0.0836
1090207;-1;460,201;458,155~1;278801.7038,5047652.8103,1.4320;278801.7038,5047652.8103,8.2270
1090206;1;467,198;467,155~1;278800.3098,5047662.8124,1.7929;278800.3098,5047662.8124,8.5879
=====
***** CHO_109_1.dat *****
Stereo Image File Name : C:\MARINE\CHO.fit
Number of Pair       : 109
Image Sequence       : 1
Number of Entities   : 2
1091131;-1;267,199;263,110~52;278809.8345,5047580.0794,0.2352;278808.4688,5047582.3969,6.8150
1090131,0,278809.8345,5047580.0794,0.2352
1081013,1,278822.5133,5047558.2047,0.9371
1080013,0,278805.0127,5047588.3456,-0.0493
1101135,1,278809.2027,5047581.2065,0.1825
1100135,0,278809.2130,5047581.1686,0.1890
1091132;1;264,199;260,110~52;278809.4312,5047580.2501,0.1650;278809.4564,5047580.1774,6.5746
1090132,0,278809.4312,5047580.2501,0.1650
1081014,1,278822.9929,5047557.0496,0.9554
1080014,0,278802.4092,5047592.2286,-0.2654
1101136,1,278810.4979,5047578.4542,0.2662
1100136,0,278809.3754,5047580.3559,0.2276
=====
***** CHO_110_0.dat *****
Stereo Image File Name : C:\MARINE\CHO.fit
Number of Pair       : 110
Image Sequence       : 0
Number of Entities   : 4
1100135;-1;328,234;323,132~52;278808.9684,5047581.6546,0.2296;278808.8416,5047581.6240,6.8031
1101135,1,278808.9684,5047581.6546,0.2296
1090131,0,278808.8029,5047581.9835,0.2321
1091131,1,278809.2130,5047581.1686,0.1890
1101050,0,278805.7904,5047587.7837,-0.0689
1111150,1,278813.1131,5047573.6124,0.5531
1100136;1;325,234;320,131~52;278808.8532,5047581.3715,0.2160;278808.5971,5047581.5881,6.8563
1101136,1,278808.8532,5047581.3715,0.2160
1090132,0,278808.8968,5047581.2598,0.1912
1091132,1,278809.3754,5047580.3559,0.2276
1110151,0,278805.4680,5047587.7986,-0.0951
1111151,1,278814.6757,5047570.1917,0.6925
1100140;-1;420,239;419,213~1;278756.5239,5047746.8153,-8.3832;278756.5239,5047746.8153,-1.5882
1100142;1;410,239;409,212~1;278756.9221,5047737.0789,-7.8451;278756.9221,5047737.0789,-1.0501
=====
***** CHO_110_1.dat *****
Stereo Image File Name : C:\MARINE\CHO.fit
Number of Pair       : 110
Image Sequence       : 1
Number of Entities   : 4
1101135;-1;283,201;277,97~52;278808.9684,5047581.6546,0.2296;278808.8416,5047581.6240,6.8031
1100135,0,278808.9684,5047581.6546,0.2296
1091131,1,278809.2027,5047581.2065,0.1825

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1090131,0,278809.4769,5047580.7436,0.2728
1111150,1,278806.8003,5047585.4633,0.0170
1110150,0,278807.3509,5047584.5194,0.0707
1101136;1;280,202;274,97~52;278808.8532,5047581.3715,0.2160;278808.5971,5047581.5881,6.8563
1100136,0,278808.8532,5047581.3715,0.2160
1091132,1,278810.4979,5047578.4542,0.2662
1090132,0,278807.8669,5047583.1188,0.0836
1111151,1,278804.2913,5047589.3358,-0.2162
1110151,0,278806.9318,5047584.7430,0.0041
1101140;-1;361,207;359,180~1;278752.2407,5047730.7854,-8.1340;278752.2407,5047730.7854,-1.3390
1101142;1;349,204;349,178~1;278745.7864,5047737.2577,-7.5680;278745.7864,5047737.2577,-0.7730
=====
***** CHO_111_0.dat *****
Stereo Image File Name : C:\MARINE\CHO.fit
Number of Pair       : 111
Image Sequence       : 0
Number of Entities   : 2
1110150;-1;353,238;348,116~52;278807.9424,5047583.2807,0.0811;278808.3705,5047582.1392,6.7527
1111150,1,278807.9424,5047583.2807,0.0811
1100135,0,278805.7904,5047587.7837,-0.0689
1101135,1,278807.3509,5047584.5194,0.0707
1120158,0,278809.6984,5047579.6636,0.3046
1121158,1,278806.0849,5047587.2485,-0.1524
1110151;1;349,239;345,116~52;278808.4415,5047581.6465,0.1140;278808.1956,5047582.0492,6.7387
1111151,1,278808.4415,5047581.6465,0.1140
1100136,0,278805.4680,5047587.7986,-0.0951
1101136,1,278806.9318,5047584.7430,0.0041
1120159,0,278809.9406,5047578.6211,0.3388
1121159,1,278803.6875,5047591.3877,-0.3829
=====
***** CHO_111_1.dat *****
Stereo Image File Name : C:\MARINE\CHO.fit
Number of Pair       : 111
Image Sequence       : 1
Number of Entities   : 4
1111147;-1;355,197;354,177~1;278713.1197,5047805.3411,-8.7973;278713.1197,5047805.3411,-2.0023
1111149;1;345,201;345,178~1;278725.4435,5047769.1935,-8.3701;278725.4435,5047769.1935,-1.5751
1111150;-1;304,205;297,81~52;278807.9424,5047583.2807,0.0811;278808.3705,5047582.1392,6.7527
1110150,0,278807.9424,5047583.2807,0.0811
1101135,1,278806.8003,5047585.4633,0.0170
1100135,0,278813.1131,5047573.6124,0.5531
1121158,1,278810.2298,5047579.0200,0.2984
1120158,0,278808.9162,5047581.4710,0.1962
1111151;1;299,206;294,82~52;278808.4415,5047581.6465,0.1140;278808.1956,5047582.0492,6.7387
1110151,0,278808.4415,5047581.6465,0.1140
1101136,1,278804.2913,5047589.3358,-0.2162
1100136,0,278814.6757,5047570.1917,0.6925
1121159,1,278810.5517,5047577.8181,0.3670
1120159,0,278809.3062,5047580.0754,0.2516
=====
***** CHO_112_0.dat *****
Stereo Image File Name : C:\MARINE\CHO.fit
Number of Pair       : 112
Image Sequence       : 0
Number of Entities   : 2
1120158;-1;386,249;379,95~52;278808.2606,5047582.9899,0.1033;278807.8628,5047583.4646,7.0608
1121158,1,278808.2606,5047582.9899,0.1033
1110150,0,278809.6984,5047579.6636,0.3046
1111150,1,278808.9162,5047581.4710,0.1962
1130024,0,278807.2787,5047585.2535,0.0262
1131024,1,278807.1311,5047585.3837,0.0158
1120159;1;382,249;376,92~52;278808.4989,5047581.9193,0.1943;278808.1433,5047582.4456,7.0970
1121159,1,278808.4989,5047581.9193,0.1943
1110151,0,278809.9406,5047578.6211,0.3388
1111151,1,278809.3062,5047580.0754,0.2516
1130025,0,278807.4096,5047584.3978,0.0849
1131025,1,278806.2837,5047586.8421,-0.0829
=====
***** CHO_112_1.dat *****
Stereo Image File Name : C:\MARINE\CHO.fit
Number of Pair       : 112

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Image Sequence      : 1
Number of Entities  : 2
1121158;-1;330,217;322,63~52;278808.2606,5047582.9899,0.1033;278807.8628,5047583.4646,7.0608
    1120158,0,278808.2606,5047582.9899,0.1033
    1111150,1,278810.2298,5047579.0200,0.2984
    1110150,0,278806.0849,5047587.2485,-0.1524
    1131024,1,278806.5673,5047586.4294,-0.0997
    1130024,0,278807.6300,5047584.2795,0.0522
1121159;1;325,216;318,59~52;278808.4989,5047581.9193,0.1943;278808.1433,5047582.4456,7.0970
    1120159,0,278808.4989,5047581.9193,0.1943
    1111151,1,278810.5517,5047577.8181,0.3670
    1110151,0,278803.6875,5047591.3877,-0.3829
    1131025,1,278807.7493,5047583.4323,0.1371
    1130025,0,278807.8413,5047583.2329,0.1502
=====
***** CHO_113_0.dat *****
Stereo Image File Name : C:\MARINE\CHO.fit
Number of Pair         : 113
Image Sequence         : 0
Number of Entities     : 8
1130024;-1;429,259;422,70~32;278808.1585,5047582.8552,0.2288;278808.0866,5047582.7237,6.6196
    1131024,1,278808.1585,5047582.8552,0.2288
    1120158,0,278807.2787,5047585.2535,0.0262
    1121158,1,278807.6300,5047584.2795,0.0522
1130025;1;425,259;418,69~32;278807.8190,5047583.3125,0.1943;278807.9640,5047582.6021,6.6406
    1131025,1,278807.8190,5047583.3125,0.1943
    1120159,0,278807.4096,5047584.3978,0.0849
    1121159,1,278807.8413,5047583.2329,0.1502
1130028;-1;318,238;316,159~32;278784.3069,5047616.6261,-0.5981;278786.3127,5047613.0701,5.7865
    1131028,1,278784.3069,5047616.6261,-0.5981
    1140171,0,278784.3990,5047616.4719,-0.5637
    1141171,1,278782.4080,5047620.0722,-0.7564
1130029;1;314,238;313,159~32;278782.1187,5047619.7066,-0.6932;278784.4462,5047615.8341,5.9738
    1131029,1,278782.1187,5047619.7066,-0.6932
    1140172,0,278787.9762,5047609.2542,-0.1958
    1141172,1,278780.8560,5047621.9691,-0.8462
1130032;-1;291,234;290,183~12;278761.7219,5047648.7108,-1.5303;278767.8124,5047638.8012,4.8301
    1131032,1,278761.7219,5047648.7108,-1.5303
1130033;1;288,234;288,181~12;278761.3796,5047648.3509,-1.5033;278767.5230,5047638.7466,5.0791
    1131033,1,278761.3796,5047648.3509,-1.5033
1130064;-1;135,207;135,163~1;278726.7419,5047650.0137,3.1736;278726.7419,5047650.0137,9.9686
1130065;1;132,206;133,161~1;278728.5821,5047647.4672,3.3151;278728.5821,5047647.4672,10.1101
=====
***** CHO_113_1.dat *****
Stereo Image File Name : C:\MARINE\CHO.fit
Number of Pair         : 113
Image Sequence         : 1
Number of Entities     : 6
1131024;-1;361,225;352,36~32;278808.1585,5047582.8552,0.2288;278808.0866,5047582.7237,6.6196
    1130024,0,278808.1585,5047582.8552,0.2288
    1121158,1,278806.5673,5047586.4294,-0.0997
    1120158,0,278807.1311,5047585.3837,0.0158
1131025;1;358,225;348,36~32;278807.8190,5047583.3125,0.1943;278807.9640,5047582.6021,6.6406
    1130025,0,278807.8190,5047583.3125,0.1943
    1121159,1,278807.7493,5047583.4323,0.1371
    1120159,0,278806.2837,5047586.8421,-0.0829
1131028;-1;279,205;275,126~32;278784.3069,5047616.6261,-0.5981;278786.3127,5047613.0701,5.7865
    1130028,0,278784.3069,5047616.6261,-0.5981
    1141171,1,278786.2133,5047613.4154,-0.4273
    1140171,0,278784.4023,5047616.4711,-0.5747
1131029;1;276,204;273,126~32;278782.1187,5047619.7066,-0.6932;278784.4462,5047615.8341,5.9738
    1130029,0,278782.1187,5047619.7066,-0.6932
    1141172,1,278785.6810,5047613.7000,-0.3947
    1140172,0,278784.7008,5047615.3633,-0.4723
1131032;-1;259,201;256,150~12;278761.7219,5047648.7108,-1.5303;278767.8124,5047638.8012,4.8301
    1130032,0,278761.7219,5047648.7108,-1.5303
1131033;1;256,201;254,148~12;278761.3796,5047648.3509,-1.5033;278767.5230,5047638.7466,5.0791
    1130033,0,278761.3796,5047648.3509,-1.5033
=====
***** CHO_114_0.dat *****
Stereo Image File Name : C:\MARINE\CHO.fit

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Number of Pair      : 114
Image Sequence      : 0
Number of Entities  : 6
1140169;-1;119,221;117,156~12;278759.2096,5047616.2425,1.2547;278755.9922,5047619.5381,7.2699
    1141169,1,278759.2096,5047616.2425,1.2547
1140170;1;116,221;115,156~12;278761.4679,5047613.5404,1.2779;278761.5528,5047613.6729,6.7916
    1141170,1,278761.4679,5047613.5404,1.2779
1140171;-1;323,239;321,149~52;278783.4867,5047618.1955,-0.6498;278783.5768,5047618.0436,6.1422
    1141171,1,278783.4867,5047618.1955,-0.6498
    1130028,0,278784.3990,5047616.4719,-0.5637
    1131028,1,278784.4023,5047616.4711,-0.5747
    1150188,0,278784.1857,5047616.9069,-0.5397
    1151188,1,278781.5053,5047621.9095,-0.8367
1140172;1;320,239;318,148~52;278784.6477,5047615.4567,-0.4985;278783.4395,5047617.7264,6.1799
    1141172,1,278784.6477,5047615.4567,-0.4985
    1130029,0,278787.9762,5047609.2542,-0.1958
    1131029,1,278784.7008,5047615.3633,-0.4723
    1150189,0,278783.4252,5047617.7213,-0.6175
    1151189,1,278782.4411,5047619.5422,-0.6978
1140178;-1;504,280;496,34~12;278808.0323,5047583.8479,0.1504;278807.9788,5047583.5334,6.2078
    1141178,1,278808.0323,5047583.8479,0.1504
1140179;1;496,281;491,34~12;278807.8484,5047583.6438,0.1288;278807.9295,5047583.1571,6.1867
    1141179,1,278807.8484,5047583.6438,0.1288
=====
***** CHO_114_1.dat *****
Stereo Image File Name : C:\MARINE\CHO.fit
Number of Pair      : 114
Image Sequence      : 1
Number of Entities  : 6
1141169;-1;80,189;78,125~12;278759.2096,5047616.2425,1.2547;278755.9922,5047619.5381,7.2699
    1140169,0,278759.2096,5047616.2425,1.2547
1141170;1;76,190;74,125~12;278761.4679,5047613.5404,1.2779;278761.5528,5047613.6729,6.7916
    1140170,0,278761.4679,5047613.5404,1.2779
1141171;-1;282,206;279,116~52;278783.4867,5047618.1955,-0.6498;278783.5768,5047618.0436,6.1422
    1140171,0,278783.4867,5047618.1955,-0.6498
    1131028,1,278786.2133,5047613.4154,-0.4273
    1130028,0,278782.4080,5047620.0722,-0.7564
    1151188,1,278784.8492,5047615.8501,-0.4982
    1150188,0,278783.8753,5047617.5280,-0.5846
1141172;1;278,206;276,116~52;278784.6477,5047615.4567,-0.4985;278783.4395,5047617.7264,6.1799
    1140172,0,278784.6477,5047615.4567,-0.4985
    1131029,1,278785.6810,5047613.7000,-0.3947
    1130029,0,278780.8560,5047621.9691,-0.8462
    1151189,1,278786.0087,5047613.1528,-0.3373
    1150189,0,278784.1409,5047616.3305,-0.5444
1141178;-1;418,244;408,2~12;278808.0323,5047583.8479,0.1504;278807.9788,5047583.5334,6.2078
    1140178,0,278808.0323,5047583.8479,0.1504
1141179;1;410,246;402,0~12;278807.8484,5047583.6438,0.1288;278807.9295,5047583.1571,6.1867
    1140179,0,278807.8484,5047583.6438,0.1288
=====
***** CHO_115_0.dat *****
Stereo Image File Name : C:\MARINE\CHO.fit
Number of Pair      : 115
Image Sequence      : 0
Number of Entities  : 4
1150184;-1;104,248;100,161~32;278758.8727,5047616.6148,-0.8609;278758.0370,5047617.3625,6.1459
    1151184,1,278758.8727,5047616.6148,-0.8609
    1160072,0,278761.0110,5047614.5730,-0.7198
    1161072,1,278759.4733,5047616.0478,-0.8486
1150185;1;100,249;97,162~32;278760.5466,5047614.4928,-0.7525;278757.3410,5047617.6158,6.1488
    1151185,1,278760.5466,5047614.4928,-0.7525
    1160071,0,278758.9173,5047616.0433,-0.8685
    1161071,1,278758.3065,5047616.6253,-0.9312
1150188;-1;335,243;332,142~52;278783.2653,5047618.7355,-0.6295;278783.2219,5047618.7278,6.1363
    1151188,1,278783.2653,5047618.7355,-0.6295
    1140171,0,278784.1857,5047616.9069,-0.5397
    1141171,1,278783.8753,5047617.5280,-0.5846
    1160069,0,278783.2991,5047618.6796,-0.6002
    1161069,1,278781.7461,5047621.6991,-0.7775
1150189;1;331,244;330,143~52;278783.0237,5047618.4959,-0.6453;278784.0726,5047616.7119,5.9057
    1151189,1,278783.0237,5047618.4959,-0.6453

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1140172,0,278783.4252,5047617.7213,-0.6175
1141172,1,278784.1409,5047616.3305,-0.5444
1160070,0,278784.7859,5047615.1203,-0.4025
1161070,1,278780.2635,5047623.8183,-0.9799
=====
***** CHO_115_1.dat *****
Stereo Image File Name : C:\MARINE\CHO.fit
Number of Pair       : 115
Image Sequence       : 1
Number of Entities   : 4
1151184;-1;63,219;58,132~32;278758.8727,5047616.6148,-0.8609;278758.0370,5047617.3625,6.1459
1150184,0,278758.8727,5047616.6148,-0.8609
1161072,1,278759.9338,5047615.6581,-0.8608
1160072,0,278759.9871,5047615.5600,-0.8332
1151185;1;58,219;55,132~32;278760.5466,5047614.4928,-0.7525;278757.3410,5047617.6158,6.1488
1150185,0,278760.5466,5047614.4928,-0.7525
1161071,1,278756.2687,5047618.3379,-1.0605
1160071,0,278762.7009,5047612.6035,-0.6108
1151188;-1;291,210;287,107~52;278783.2653,5047618.7355,-0.6295;278783.2219,5047618.7278,6.1363
1150188,0,278783.2653,5047618.7355,-0.6295
1141171,1,278784.8492,5047615.8501,-0.4982
1140171,0,278781.5053,5047621.9095,-0.8367
1161069,1,278783.4800,5047618.3813,-0.5756
1160069,0,278783.3027,5047618.6753,-0.6112
1151189;1;287,210;284,109~52;278783.0237,5047618.4959,-0.6453;278784.0726,5047616.7119,5.9057
1150189,0,278783.0237,5047618.4959,-0.6453
1141172,1,278786.0087,5047613.1528,-0.3373
1140172,0,278782.4411,5047619.5422,-0.6978
1161070,1,278784.6706,5047615.5923,-0.4173
1160070,0,278783.9910,5047616.7859,-0.4865
=====
***** CHO_116_0.dat *****
Stereo Image File Name : C:\MARINE\CHO.fit
Number of Pair       : 116
Image Sequence       : 0
Number of Entities   : 6
1160067;-1;300,232;297,167~32;278762.7178,5047647.5596,-1.3663;278760.9719,5047650.3114,5.1090
1161067,1,278762.7178,5047647.5596,-1.3663
1170192,0,278755.8148,5047659.6067,-1.9776
1171192,1,278762.6875,5047647.6028,-1.2517
1160068;1;297,232;295,166~32;278762.4505,5047647.2967,-1.3467;278760.7449,5047650.2106,5.2234
1161068,1,278762.4505,5047647.2967,-1.3467
1170193,0,278757.3863,5047656.0519,-1.7838
1171193,1,278761.3215,5047649.2318,-1.3772
1160069;-1;351,244;348,129~52;278782.9826,5047619.3513,-0.6149;278783.5359,5047618.1530,5.8531
1161069,1,278782.9826,5047619.3513,-0.6149
1150188,0,278783.2991,5047618.6796,-0.6002
1151188,1,278783.3027,5047618.6753,-0.6112
1170194,0,278784.2884,5047616.6498,-0.4137
1171194,1,278780.4435,5047624.6386,-0.9905
1160070;1;348,244;345,128~52;278783.5776,5047617.6470,-0.5245;278783.3798,5047618.0168,5.8881
1161070,1,278783.5776,5047617.6470,-0.5245
1150189,0,278784.7859,5047615.1203,-0.4025
1151189,1,278783.9910,5047616.7859,-0.4865
1170195,0,278783.2763,5047618.2846,-0.5338
1171195,1,278782.7423,5047619.3588,-0.6247
1160072;-1;83,251;79,145~42;278758.1233,5047617.2094,-0.9901;278758.5320,5047616.9325,6.5128
1161072,1,278758.1233,5047617.2094,-0.9901
1150184,0,278761.0110,5047614.5730,-0.7198
1151184,1,278759.9871,5047615.5600,-0.8332
1170198,0,278759.5710,5047615.9068,-0.9036
1160071;1;79,251;76,145~42;278757.6670,5047617.1691,-0.9867;278756.1041,5047618.7966,6.7955
1161071,1,278757.6670,5047617.1691,-0.9867
1150185,0,278758.9173,5047616.0433,-0.8685
1151185,1,278762.7009,5047612.6035,-0.6108
1170199,0,278759.6614,5047615.3878,-0.8609
=====
***** CHO_116_1.dat *****
Stereo Image File Name : C:\MARINE\CHO.fit
Number of Pair       : 116
Image Sequence       : 1

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Number of Entities      : 6
1161067;-1;264,199;261,135~32;278762.7178,5047647.5596,-1.3663;278760.9719,5047650.3114,5.1090
    1160067,0,278762.7178,5047647.5596,-1.3663
    1171192,1,278759.7830,5047652.4376,-1.5107
    1170192,0,278760.8439,5047650.6609,-1.5050
1161068;1;261,199;259,134~32;278762.4505,5047647.2967,-1.3467;278760.7449,5047650.2106,5.2234
    1160068,0,278762.4505,5047647.2967,-1.3467
    1171193,1,278761.0334,5047649.6551,-1.4028
    1170193,0,278761.1491,5047649.4310,-1.4332
1161069;-1;303,210;298,95~52;278782.9826,5047619.3513,-0.6149;278783.5359,5047618.1530,5.8531
    1160069,0,278782.9826,5047619.3513,-0.6149
    1151188,1,278783.4800,5047618.3813,-0.5756
    1150188,0,278781.7461,5047621.6991,-0.7775
    1171194,1,278784.0118,5047617.4315,-0.4434
    1170194,0,278783.7352,5047617.9372,-0.4912
1161070;1;299,211;295,95~52;278783.5776,5047617.6470,-0.5245;278783.3798,5047618.0168,5.8881
    1160070,0,278783.5776,5047617.6470,-0.5245
    1151189,1,278784.6706,5047615.5923,-0.4173
    1150189,0,278780.2635,5047623.8183,-0.9799
    1171195,1,278783.6181,5047617.5940,-0.5031
    1170195,0,278783.4642,5047617.8679,-0.5129
1161072;-1;39,222;33,115~42;278758.1233,5047617.2094,-0.9901;278758.5320,5047616.9325,6.5128
    1160072,0,278758.1233,5047617.2094,-0.9901
    1151184,1,278759.9338,5047615.6581,-0.8608
    1150184,0,278759.4733,5047616.0478,-0.8486
    1170198,0,278763.4591,5047612.6433,-0.6322
1161071;1;35,222;31,113~42;278757.6670,5047617.1691,-0.9867;278756.1041,5047618.7966,6.7955
    1160071,0,278757.6670,5047617.1691,-0.9867
    1151185,1,278756.2687,5047618.3379,-1.0605
    1150185,0,278758.3065,5047616.6253,-0.9312
    1170199,0,278764.3467,5047611.5087,-0.5318

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***** CHO_117_0.dat *****
Stereo Image File Name : C:\MARINE\CHO.fit
Number of Pair         : 117
Image Sequence         : 0
Number of Entities     : 6
1170192;-1;305,231;302,157~42;278760.9992,5047650.4091,-1.3759;278759.0539,5047653.6282,5.4880
    1171192,1,278760.9992,5047650.4091,-1.3759
    1160067,0,278755.8148,5047659.6067,-1.9776
    1161067,1,278760.8439,5047650.6609,-1.5050
    1181201,1,278759.7482,5047652.6248,-1.6030
1170193;1;302,231;300,158~42;278760.5737,5047650.4552,-1.4198;278761.0188,5047649.6784,5.2835
    1171193,1,278760.5737,5047650.4552,-1.4198
    1160068,0,278757.3863,5047656.0519,-1.7838
    1161068,1,278761.1491,5047649.4310,-1.4332
    1181200,1,278758.4511,5047654.1978,-1.6905
1170194;-1;376,248;372,107~52;278783.4983,5047618.4845,-0.5132;278784.0782,5047617.0213,5.8076
    1171194,1,278783.4983,5047618.4845,-0.5132
    1160069,0,278784.2884,5047616.6498,-0.4137
    1161069,1,278783.7352,5047617.9372,-0.4912
    1180079,0,278782.6374,5047620.4499,-0.6885
    1181079,1,278784.7439,5047615.6367,-0.3034
1170195;1;371,248;368,107~52;278783.3092,5047618.2281,-0.5157;278783.4892,5047617.8295,5.9120
    1171195,1,278783.3092,5047618.2281,-0.5157
    1160070,0,278783.2763,5047618.2846,-0.5338
    1161070,1,278783.4642,5047617.8679,-0.5129
    1180081,0,278783.2663,5047618.3128,-0.5270
    1181081,1,278783.5874,5047617.7014,-0.4857
1170198;-1;56,257;51,138~32;278759.5710,5047615.9068,-0.9036;278758.1960,5047617.2010,6.3867
    1160072,0,278759.5710,5047615.9068,-0.9036
    1161072,1,278763.4591,5047612.6433,-0.6322
    1180083,0,278760.2865,5047615.3345,-0.9563
1170199;1;51,257;47,138~32;278759.6614,5047615.3878,-0.8609;278758.6954,5047616.4147,6.3275
    1160071,0,278759.6614,5047615.3878,-0.8609
    1161071,1,278764.3467,5047611.5087,-0.5318
    1180082,0,278760.1884,5047614.9879,-0.9503

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***** CHO_117_1.dat *****
Stereo Image File Name : C:\MARINE\CHO.fit
Number of Pair         : 117

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Image Sequence      : 1
Number of Entities  : 4
1171192;-1;268,196;265,125~42;278760.9992,5047650.4091,-1.3759;278759.0539,5047653.6282,5.4880
    1170192,0,278760.9992,5047650.4091,-1.3759
    1161067,1,278759.7830,5047652.4376,-1.5107
    1160067,0,278762.6875,5047647.6028,-1.2517
    1181201,1,278767.5870,5047639.2885,-0.7560
1171193;1;265,197;262,125~42;278760.5737,5047650.4552,-1.4198;278761.0188,5047649.6784,5.2835
    1170193,0,278760.5737,5047650.4552,-1.4198
    1161068,1,278761.0334,5047649.6551,-1.4028
    1160068,0,278761.3215,5047649.2318,-1.3772
    1181200,1,278766.5176,5047640.5570,-0.8631
1171194;-1;321,214;314,73~52;278783.4983,5047618.4845,-0.5132;278784.0782,5047617.0213,5.8076
    1170194,0,278783.4983,5047618.4845,-0.5132
    1161069,1,278784.0118,5047617.4315,-0.4434
    1160069,0,278780.4435,5047624.6386,-0.9905
    1181079,1,278783.5632,5047618.3160,-0.5277
    1180079,0,278783.0121,5047619.4589,-0.5943
1171195;1;316,215;311,73~52;278783.3092,5047618.2281,-0.5157;278783.4892,5047617.8295,5.9120
    1170195,0,278783.3092,5047618.2281,-0.5157
    1161070,1,278783.6181,5047617.5940,-0.5031
    1160070,0,278782.7423,5047619.3588,-0.6247
    1181081,1,278784.1658,5047616.5330,-0.3925
    1180081,0,278783.2506,5047618.3422,-0.5408
=====
***** CHO_118_0.dat *****
Stereo Image File Name : C:\MARINE\CHO.fit
Number of Pair         : 118
Image Sequence         : 0
Number of Entities     : 4
1180079;-1;410,253;406,74~32;278782.9085,5047619.7296,-0.6685;278783.0452,5047619.1130,6.0055
    1181079,1,278782.9085,5047619.7296,-0.6685
    1170194,0,278782.6374,5047620.4499,-0.6885
    1171194,1,278783.0121,5047619.4589,-0.5943
1180081;1;406,254;403,74~32;278782.7593,5047619.6153,-0.6792;278782.9388,5047619.0271,5.9923
    1181081,1,278782.7593,5047619.6153,-0.6792
    1170195,0,278783.2663,5047618.3128,-0.5270
    1171195,1,278783.2506,5047618.3422,-0.5408
1180083;-1;17,261;10,119~12;278760.2865,5047615.3345,-0.9563;278759.8774,5047615.7028,5.9204
    1170198,0,278760.2865,5047615.3345,-0.9563
1180082;1;11,262;7,118~12;278760.1884,5047614.9879,-0.9503;278758.2180,5047616.7507,6.0988
    1170199,0,278760.1884,5047614.9879,-0.9503
=====
***** CHO_118_1.dat *****
Stereo Image File Name : C:\MARINE\CHO.fit
Number of Pair         : 118
Image Sequence         : 1
Number of Entities     : 4
1181079;-1;347,221;340,39~32;278782.9085,5047619.7296,-0.6685;278783.0452,5047619.1130,6.0055
    1180079,0,278782.9085,5047619.7296,-0.6685
    1171194,1,278783.5632,5047618.3160,-0.5277
    1170194,0,278784.7439,5047615.6367,-0.3034
1181081;1;343,221;337,40~32;278782.7593,5047619.6153,-0.6792;278782.9388,5047619.0271,5.9923
    1180081,0,278782.7593,5047619.6153,-0.6792
    1171195,1,278784.1658,5047616.5330,-0.3925
    1170195,0,278783.5874,5047617.7014,-0.4857
1181201;-1;273,194;269,113~22;278767.5870,5047639.2885,-0.7560;278754.4399,5047661.3847,5.7739
    1171192,1,278767.5870,5047639.2885,-0.7560
    1170192,0,278759.7482,5047652.6248,-1.6030
1181200;1;270,194;267,113~22;278766.5176,5047640.5570,-0.8631;278761.0137,5047649.7403,5.2338
    1171193,1,278766.5176,5047640.5570,-0.8631
    1170193,0,278758.4511,5047654.1978,-1.6905

```

Appendix B(1). Data Source

File Name	: C:\CFM\CFM	Code	: 80000
Number of Pair	: 7	Type of Entity	: Line
Number of Entities	: 33	Point 1	:
Type of Entity	: Line	606078.027,230348.958,243.589;271,70;310,68	
Point 1	:	Point 2	:
606047.904,230340.651,235.201;78,116;133,115		606077.981,230348.191,229.809;269,143;308,140	
Point 2	:	Code	: 80000
606064.498,230327.592,234.237;156,116;201,114		Type of Entity	: Line
Code	: 70000	Point 1	:
Type of Entity	: Line	606063.949,230349.362,231.542;147,130;196,129	
Point 1	:	Point 2	:
606064.498,230327.592,234.237;156,116;201,114		606054.880,230393.248,232.647;191,131;241,127	
Point 2	:	Code	: 90000
606058.264,230348.732,233.589;167,125;215,122		Type of Entity	: Line
Code	: 70000	Point 1	:
Type of Entity	: Line	606054.172,230395.054,230.870;191,137;241,134	
Point 1	:	Point 2	:
606058.264,230348.732,233.589;167,125;215,122		606063.278,230350.731,230.347;147,138;196,135	
Point 2	:	Code	: 90000
606056.515,230323.503,232.520;77,127;130,124		Type of Entity	: Line
Code	: 70000	Point 1	:
Type of Entity	: Line	606091.184,230302.125,228.394;311,170;320,167	
Point 1	:	Point 2	:
606094.644,230267.024,228.243;436,204;408,200		606093.435,230286.431,228.028;340,235;277,228	
Point 2	:	Code	: 90000
606094.686,230264.125,228.118;460,224;410,221		Type of Entity	: Line
Code	: 70000	Point 1	:
Type of Entity	: Line	606096.003,230291.275,228.252;440,202;416,198	
Point 1	:	Point 2	:
606078.500,230347.450,230.461;280,142;320,139		606096.123,230288.452,228.161;464,219;421,216	
Point 2	:	Code	: 90000
606076.996,230353.526,244.882;279,78;321,75		Type of Entity	: Line
Code	: 70000	Point 1	:
Type of Entity	: Line	606078.220,230354.960,244.789;265,57;301,55	
Point 1	:	Point 2	:
606080.901,230326.620,240.731;276,78;318,75		606079.723,230347.158,228.999;264,147;301,144	
Point 2	:	Code	: 90000
606076.522,230352.477,229.966;276,142;316,139		Type of Entity	: Line
Code	: 70000	Point 1	:
Type of Entity	: Line	606077.685,230354.140,244.621;261,57;297,55	
Point 1	:	Point 2	:
606046.884,230412.095,233.566;197,131;248,127		606078.012,230351.047,229.267;259,147;296,144	
Point 2	:	Code	: 90000
606060.986,230351.322,231.894;165,131;212,128		Type of Entity	: Line
Code	: 80000	Point 1	:
Type of Entity	: Line	606050.402,230385.711,231.512;132,128;183,127	
Point 1	:	Point 2	:
606057.035,230380.853,231.020;198,138;248,133		606056.028,230394.686,232.362;181,127;231,123	
Point 2	:	Code	: 100000
606057.005,230362.045,230.528;166,137;214,136		Type of Entity	: Line
Code	: 80000	Point 1	:
Type of Entity	: Line	606058.880,230387.090,230.440;182,134;231,131	
Point 1	:	Point 2	:
606089.013,230276.725,227.889;167,217;131,214		606042.317,230402.373,230.422;130,133;183,132	
Point 2	:	Code	: 100000
606088.906,230275.563,227.752;137,234;93,227		Type of Entity	: Line
Code	: 80000	Point 1	:
Type of Entity	: Line	606096.631,230303.519,228.228;445,199;424,195	
Point 1	:	Point 2	:
606095.420,230279.213,228.279;439,203;414,198		606096.699,230300.872,228.123;465,215;427,211	
Point 2	:	Code	: 100000
606095.441,230276.106,228.173;463,222;415,219		Type of Entity	: Line
Code	: 80000	Point 1	:
Type of Entity	: Line	606096.489,230303.340,228.224;441,199;419,196	
Point 1	:	Point 2	:
606078.658,230349.762,243.834;275,70;314,68		606096.557,230300.509,228.161;462,216;421,211	
Point 2	:	Code	: 100000
606078.817,230348.094,229.946;274,143;313,140		Type of Entity	: Line

```

Point 1 :
606081.214,230344.983,242.664;250,37;284,34
Point 2 :
606081.445,230343.402,228.669;250,147;284,144
Code : 100000
Type of Entity      : Line
Point 1 :
606082.105,230339.679,241.447;246,37;279,34
Point 2 :
606080.487,230344.364,228.616;244,147;278,144
Code : 100000
Type of Entity      : Line
Point 1 :
606065.335,230361.793,231.055;117,130;163,127
Point 2 :
606060.758,230387.644,231.584;167,130;216,127
Code : 110000
Type of Entity      : Line
Point 1 :
606060.758,230387.644,231.584;167,130;216,127
Point 2 :
606048.651,230416.726,230.303;166,136;216,134
Code : 110000
Type of Entity      : Line
Point 1 :
606048.651,230416.726,230.303;166,136;216,134
Point 2 :
606059.006,230373.440,230.362;110,135;164,134
Code : 110000
Type of Entity      : Line
Point 1 :
606086.809,230315.735,229.121;80,162;72,161
Point 2 :
606088.260,230314.768,229.199;116,161;103,158
Code : 110000
Type of Entity      : Line
Point 1 :
606088.260,230314.768,229.199;116,161;103,158
Point 2 :
606088.285,230314.553,228.629;116,179;99,176
Code : 110000
Type of Entity      : Line
Point 1 :
606088.285,230314.553,228.629;116,179;99,176
Point 2 :
606088.639,230313.012,228.493;95,190;74,186
Code : 110000
Type of Entity      : Line
Point 1 :
606088.305,230313.551,228.401;95,191;74,187
Point 2 :
606087.372,230313.238,228.456;40,191;28,190
Code : 110000
Type of Entity      : Line
Point 1 :
606084.060,230338.835,240.767;222,8;247,10
Point 2 :
606082.939,230341.538,228.221;222,156;251,154
Code : 110000
Type of Entity      : Line
Point 1 :
606082.322,230343.058,242.042;216,8;241,10
Point 2 :
606081.306,230344.497,227.980;215,156;244,154
Code : 110000
Type of Entity      : Line
Point 1 :
606082.335,230343.030,242.079;214,8;240,7
Point 2 :
606083.174,230338.325,228.385;211,155;240,153
Code : 110000

```

Appendix C(1). Results

```

=====
***** CFM_7_0.dat *****
Stereo Image File Name : C:\CFM\CFM.fit
Number of Pair          : 7
Image Sequence          : 0
Number of Entities      : 2
70005;-1;276,142;276,78~32;606078.7484,230338.5059,229.9476;606074.3861,230362.0939,245.3791
    71005,1,606078.7484,230338.5059,229.9476
    80011,0,606073.2534,230372.7646,229.6685
    81011,1,606075.6201,230357.8981,229.7574
70004;1;280,142;279,78~32;606079.2943,230339.3111,229.9902;606074.8581,230363.0308,245.5502
    71004,1,606079.2943,230339.3111,229.9902
    80010,0,606073.4130,230377.8909,229.7388
    81010,1,606076.0840,230360.2569,229.8093
=====
***** CFM_7_1.dat *****
Stereo Image File Name : C:\CFM\CFM.fit
Number of Pair          : 7
Image Sequence          : 1
Number of Entities      : 2
71005;-1;316,139;318,75~32;606078.7484,230338.5059,229.9476;606074.3861,230362.0939,245.3791
    70005,0,606078.7484,230338.5059,229.9476
    81011,1,606072.1711,230373.9048,229.7865
    80011,0,606103.4744,230208.2437,230.0016
71004;1;320,139;321,75~32;606079.2943,230339.3111,229.9902;606074.8581,230363.0308,245.5502
    70004,0,606079.2943,230339.3111,229.9902
    81010,1,606072.2585,230378.9135,229.8321
    80010,0,606106.9811,230185.7653,229.9971
=====
***** CFM_8_0.dat *****
Stereo Image File Name : C:\CFM\CFM.fit
Number of Pair          : 8
Image Sequence          : 0
Number of Entities      : 2
80011;-1;269,143;271,70~52;606078.9187,230342.4899,229.6079;606077.5330,230349.1452,243.0431
    81011,1,606078.9187,230342.4899,229.6079
    90017,0,606075.8199,230360.3101,228.9721
    91017,1,606076.5547,230355.5671,229.0924
    70005,0,606073.2534,230372.7646,229.6685
    71005,1,606103.4744,230208.2437,230.0016
80010;1;274,143;275,70~52;606079.5155,230343.4319,229.6534;606078.0656,230349.7571,243.1769
    81010,1,606079.5155,230343.4319,229.6534
    90016,0,606077.3723,230356.7970,229.0731
    91016,1,606077.7152,230354.0702,229.1604
    70004,0,606073.4130,230377.8909,229.7388
    71004,1,606106.9811,230185.7653,229.9971
=====
***** CFM_8_1.dat *****
Stereo Image File Name : C:\CFM\CFM.fit
Number of Pair          : 8
Image Sequence          : 1
Number of Entities      : 2
81011;-1;308,140;310,68~52;606078.9187,230342.4899,229.6079;606077.5330,230349.1452,243.0431
    80011,0,606078.9187,230342.4899,229.6079
    91017,1,606075.4643,230359.5282,229.1172
    90017,0,606092.8971,230279.4635,229.8987
    71005,1,606072.1711,230373.9048,229.7865
    70005,0,606075.6201,230357.8981,229.7574
81010;1;313,140;314,68~52;606079.5155,230343.4319,229.6534;606078.0656,230349.7571,243.1769
    80010,0,606079.5155,230343.4319,229.6534
    91016,1,606077.0406,230356.4890,229.1917
    90016,0,606092.8316,230280.1634,229.8962
    71004,1,606072.2585,230378.9135,229.8321
    70004,0,606076.0840,230360.2569,229.8093
=====
***** CFM_9_0.dat *****
Stereo Image File Name : C:\CFM\CFM.fit
Number of Pair          : 9

```



```

Image Sequence      : 0
Number of Entities  : 2
90017;-1;259,147;261,57~52;606079.8402,230342.5882,228.8505;606079.2558,230344.8600,242.1958
    91017,1,606079.8402,230342.5882,228.8505
    100023,0,606075.1120,230364.9418,228.0786
    101023,1,606077.2235,230354.8247,228.3865
    80011,0,606075.8199,230360.3101,228.9721
    81011,1,606092.8971,230279.4635,229.8987
90016;1;264,147;265,57~52;606080.3267,230343.3830,228.8767;606079.6617,230345.3884,242.3186
    91016,1,606080.3267,230343.3830,228.8767
    100022,0,606075.8230,230365.7534,228.1297
    101022,1,606077.8733,230355.4353,228.4245
    80010,0,606077.3723,230356.7970,229.0731
    81010,1,606092.8316,230280.1634,229.8962
=====
***** CFM_9_1.dat *****
Stereo Image File Name : C:\CFM\CFM.fit
Number of Pair         : 9
Image Sequence         : 1
Number of Entities     : 2
91017;-1;296,144;297,55~52;606079.8402,230342.5882,228.8505;606079.2558,230344.8600,242.1958
    90017,0,606079.8402,230342.5882,228.8505
    101023,1,606075.2219,230361.4869,228.3099
    100023,0,606082.8610,230332.5896,228.8778
    81011,1,606075.4643,230359.5282,229.1172
    80011,0,606076.5547,230355.5671,229.0924
91016;1;301,144;301,55~52;606080.3267,230343.3830,228.8767;606079.6617,230345.3884,242.3186
    90016,0,606080.3267,230343.3830,228.8767
    101022,1,606075.9215,230362.2178,228.3405
    100022,0,606086.0893,230321.3690,229.1564
    81010,1,606077.0406,230356.4890,229.1917
    80010,0,606077.7152,230354.0702,229.1604
=====
***** CFM_10_0.dat *****
Stereo Image File Name : C:\CFM\CFM.fit
Number of Pair         : 10
Image Sequence         : 0
Number of Entities     : 2
100023;-1;244,147;246,37~42;606080.9480,230342.1930,228.4798;606080.1073,230344.8909,241.8764
    101023,1,606080.9480,230342.1930,228.4798
    111032,1,606079.3014,230348.8635,227.8872
    90017,0,606075.1120,230364.9418,228.0786
    91017,1,606082.8610,230332.5896,228.8778
100022;1;250,147;250,37~42;606081.3990,230342.9553,228.5042;606079.6498,230348.4287,242.6654
    101022,1,606081.3990,230342.9553,228.5042
    111031,1,606080.0491,230348.7513,227.9397
    90016,0,606075.8230,230365.7534,228.1297
    91016,1,606086.0893,230321.3690,229.1564
=====
***** CFM_10_1.dat *****
Stereo Image File Name : C:\CFM\CFM.fit
Number of Pair         : 10
Image Sequence         : 1
Number of Entities     : 2
101023;-1;278,144;279,34~42;606080.9480,230342.1930,228.4798;606080.1073,230344.8909,241.8764
    100023,0,606080.9480,230342.1930,228.4798
    111032,1,606078.6325,230350.4875,227.9028
    91017,1,606075.2219,230361.4869,228.3099
    90017,0,606077.2235,230354.8247,228.3865
101022;1;284,144;284,34~42;606081.3990,230342.9553,228.5042;606079.6498,230348.4287,242.6654
    100022,0,606081.3990,230342.9553,228.5042
    111031,1,606079.5550,230349.9554,227.9646
    91016,1,606075.9215,230362.2178,228.3405
    90016,0,606077.8733,230355.4353,228.4245
=====
***** CFM_11_0.dat *****
Stereo Image File Name : C:\CFM\CFM.fit
Number of Pair         : 11
Image Sequence         : 0
Number of Entities     : 2
110032;-1;215,156;216,8~12;606082.3590,230340.7615,227.9410;606082.5189,230340.0961,240.3915

```

```

111032,1,606082.3590,230340.7615,227.9410
110031;1;222,156;222,8~12;606082.7228,230341.3983,227.9461;606082.8497,230340.4500,240.5082
111031,1,606082.7228,230341.3983,227.9461
=====
***** CFM_11_1.dat *****
Stereo Image File Name : C:\CFM\CFM.fit
Number of Pair      : 11
Image Sequence      : 1
Number of Entities  : 2
111032;-1;244,154;241,10~32;606082.3590,230340.7615,227.9410;606082.5189,230340.0961,240.3915
110032,0,606082.3590,230340.7615,227.9410
101023,1,606078.6325,230350.4875,227.9028
100023,0,606079.3014,230348.8635,227.8872
111031;1;251,154;247,10~32;606082.7228,230341.3983,227.9461;606082.8497,230340.4500,240.5082
110031,0,606082.7228,230341.3983,227.9461
101022,1,606079.5550,230349.9554,227.9646
100022,0,606080.0491,230348.7513,227.9397

```

Appendix D. Data structure and Classes

1. Struct for ground coordinates.

```
struct GrndCoord
{
    long ID;           // Line ID with matched
    int LorR;
    double x,y,z;
    struct GrndCoord *Next;
};
```

2. Class for one of stereo image and extracted lines

```
class IPoles
{
public:
    char StereoImageFile[_MAX_PATH];
    char DataFileName[_MAX_PATH];
    LINEDATA *ILinesD;
    LINEDATA *MLinesD;
    struct Point3D *ApproximateC;
    struct Point3D *TopEndC;
    int *PTStatus;
    struct GrndCoord **GC;
    long No;
    int LorR;
    long ILine;
    camera_type Camera;
    int status;

    // status = 0: Read in OK
    // status >= 1: Not ready 4 is file open error

    void SetCoordMem();
    IPoles(char * DataFile, int flag);
    ~IPoles();
    LINEDATA *GetILinesD(){return ILinesD;};
    LINEDATA *GetMLinesD(){return MLinesD;};
    void GetApproximate();
    void GetBackProjection(camera_type * cam);
};

void IPoles::SetCoordMem() // Initialize coordinate memory block
{
    if( TopEndC == NULL )
        TopEndC = new struct Point3D[ILine];
    if( ApproximateC == NULL )
        ApproximateC = new struct Point3D[ILine];
    if( PTStatus == NULL )
        PTStatus = new int[ILine];
    if( GC == NULL )
    {
        GC = new struct GrndCoord * [ILine];
        int i;
        for(i=0;i<ILine;i++)
            GC[i] = NULL;
    }
}

IPoles::IPoles(char * DataFile, int flag) // constructor of the IPoles class
{
    FILE *fp;

    ILinesD = NULL;
    MLinesD = NULL;
```

```

ApproximateC = NULL;
PTStatus = NULL;
TopEndC = NULL;
GC = NULL;
ILine = 0;
char strTmp[256];
long ID,IID;
short C, x1, y1, x2, y2;
int Ps, Lr;
double Xg, Yg, Zg;
double Xg1, Yg1, Zg1;
double Xg2, Yg2, Zg2;
struct GrndCoord * TmpGC;

strcpy(DataFileName, DataFile);
fp = fopen(DataFile, "r");
if(fp == NULL)
{
    status |= 4; // open file error
}
else
{
    fgets(strTmp, 256, fp);
    strcpy(StereoImageFile, GetValue(strTmp));
    fgets(strTmp, 256, fp);
    sscanf(GetValue(strTmp), "%ld", &No);
    fgets(strTmp, 256, fp);
    sscanf(GetValue(strTmp), "%d", &LorR);
    fgets(strTmp, 256, fp);
    sscanf(GetValue(strTmp), "%ld", &ILine);
    ILinesD = new struct LineData[ILine];
    SetCoordMem();
    if(ILinesD == NULL)
    {
        status |= 2;
        fclose(fp);
    }
    else
    {
        int i, j, Cn;
        char *pStr;

        for(i=0;i<ILine;i++)
        {
            Ps = 0;
            fgets(strTmp, 256, fp);
            pStr = strchr(strTmp, '~');
            if(pStr)
            {
                pStr = strchr(pStr, ';');
                if(pStr != NULL)
                {
                    *pStr = '\0';
                    pStr++;
                }
                sscanf(strTmp, "%ld;%d;%d;%d;%d~%d",
                    &ID, &C, &x1, &y1, &x2, &y2,
                    &Ps);
                Cn = Ps / 10;
                Ps -= Cn * 10;
                if(pStr == NULL) Ps = 0;
                if(Ps > 0)
                    sscanf(pStr, "%lf;%lf;%lf;%lf;%lf;%lf",
                        &Xg1, &Yg1, &Zg1,
                        &Xg2, &Yg2, &Zg2);

                if(Cn > 0)
                {
                    if( GC[i] != NULL)
                    {
                        TmpGC = GC[i];

```

```

        while(TmpGC->Next != NULL)
            TmpGC = TmpGC->Next;
    }
    for(j=0;j<Cn;j++)
    {
        fscanf(fp, "%ld,%d,%lf,%lf,%lf\n",
                &IID, &Lr,
                &Xg, &Yg, &Zg
        );
        if( GC[i] == NULL)
        {
            GC[i] = new struct GrndCoord;
            TmpGC = GC[i];
            TmpGC->Next = NULL;
        }
        else
        {
            TmpGC->Next = new struct GrndCoord;
            TmpGC = TmpGC->Next;
            TmpGC->Next = NULL;
        }
        TmpGC->ID = IID;
        TmpGC->LorR = Lr;
        TmpGC->x = Xg;
        TmpGC->y = Yg;
        TmpGC->z = Zg;
    }
}
else
    sscanf(strTmp, "%ld;%d;%d;%d;%d;%d",
            &IID, &C, &x1, &y1, &x2, &y2);
ILinesD[i].LineID = IID;
PTStatus[i] = Ps;
if(y1 > y2)
{
    ILinesD[i].Bp.wx = x1;
    ILinesD[i].Bp.wy = y1;
    ILinesD[i].Ep.wx = x2;
    ILinesD[i].Ep.wy = y2;
    ILinesD[i].Code = C;
    if(Ps > 0)
    {
        ApproximateC[i].x = Xg1;
        ApproximateC[i].y = Yg1;
        ApproximateC[i].z = Zg1;
        TopEndC[i].x = Xg2;
        TopEndC[i].y = Yg2;
        TopEndC[i].z = Zg2;
    }
}
else
{
    ILinesD[i].Bp.wx = x2;
    ILinesD[i].Bp.wy = y2;
    ILinesD[i].Ep.wx = x1;
    ILinesD[i].Ep.wy = y1;
    ILinesD[i].Code = -C;
    if(Ps > 0)
    {
        ApproximateC[i].x = Xg2;
        ApproximateC[i].y = Yg2;
        ApproximateC[i].z = Zg2;
        TopEndC[i].x = Xg1;
        TopEndC[i].y = Yg1;
        TopEndC[i].z = Zg1;
    }
}
ILinesD[i].Match = 0;
}

```

```

        fclose(fp);
        if(LPReadImage(StereoImageFile, No, LorR))
        {
            status |= 8;
        }
        memcpy(&Camera, &MarHeader.camera[LorR], sizeof(camera_type));
    }
    status = 0;
}

IPoles::~IPoles()
{
    ILine = 0;
    if(ILinesD != NULL) delete [] ILinesD;
    if(MLinesD != NULL) delete [] MLinesD;
    if(ApproximateC != NULL) delete [] ApproximateC;
    if(TopEndC != NULL) delete [] TopEndC;
    if(PTStatus != NULL) delete [] PTStatus;

    struct GrndCoord * TmpGC;
    if (GC != NULL )
    {
        int i;
        for(i=0;i<ILine;i++)
        {
            if(GC[i] != NULL)
            {
                TmpGC = GC[i];
                while(TmpGC != NULL)
                {
                    TmpGC = TmpGC->Next;
                    delete TmpGC;
                }
            }
        }
        delete [] GC;
    }
}

void IPoles::GetApproximate()
{
    int i;
    short x1,y1,x2,y2;

    if( ApproximateC == NULL )
        ApproximateC = new struct Point3D[ILine];
    if( PTStatus == NULL )
        PTStatus = new int[ILine];
    if (ApproximateC == NULL)
    {
        status |= 1;
    }
    else
    {
        for(i=0;i<ILine;i++)
        {
            if(PTStatus[i] == 2) continue;
            if(
                ILinesD[i].Ep.wy > ILinesD[i].Bp.wy)
            {
                x1 = ILinesD[i].Ep.wx;
                y1 = ILinesD[i].Ep.wy;
                x2 = ILinesD[i].Bp.wx;
                y2 = ILinesD[i].Bp.wy;
            }
            else
            {
                x1 = ILinesD[i].Bp.wx;
                y1 = ILinesD[i].Bp.wy;
                x2 = ILinesD[i].Ep.wx;
            }
        }
    }
}

```

```

        y2 = ILinesD[i].Ep.wy;
    }
    GetApproximateCoord(x1, y1, x2, y2,
        &ApproximateC[i].x,
        &ApproximateC[i].y,
        &ApproximateC[i].z,
        Camera);
    TopEndC[i].x = ApproximateC[i].x;
    TopEndC[i].y = ApproximateC[i].y;
    TopEndC[i].z = ApproximateC[i].z + Cylinder.Length;
    PTStatus[i] = 1;
    }
}

void IPoles::GetBackProjection(camera_type * cam)
{
    int i;
    MLinesD = new struct LineData[ILine];

    if (MLinesD == NULL)
    {
        status |= 1;
    }
    else
    {
        struct ImagePos Ic;
        struct Point3D pt;
        for(i=0; i<ILine; i++)
        {
            pt = ApproximateC[i];
            BackProject(cam, &pt, &Ic);
            MLinesD[i].Bp.wx = Ic.wx;
            MLinesD[i].Bp.wy = Ic.wy;
            if(PTStatus[i] == 2)
                pt = TopEndC[i];
            else
                pt.z += Cylinder.Length;
            BackProject(cam, &pt, &Ic);
            MLinesD[i].Ep.wx = Ic.wx;
            MLinesD[i].Ep.wy = Ic.wy;
            if(
                ILinesD[i].Ep.wy > ILinesD[i].Bp.wy)
            {
                MLinesD[i].Code = - ILinesD[i].Code;
            }
            else
            {
                MLinesD[i].Code = ILinesD[i].Code;
            }
            MLinesD[i].LineID = ILinesD[i].LineID;
            MLinesD[i].Match = ILinesD[i].Match;
        }
    }
};

```

3. Structure of camera external orient parameters

```

typedef struct    /* rotation matrix */
{
    double m11,m12,m13;
    double m21,m22,m23;
    double m31,m32,m33;
}  rotmat_type;

typedef struct    /* camera system from GPS/INS -- GEOFIT */
{
    double x,y,z;    /* perspective centre absolute position (m) */

```

```

double sx,sy,sz; /* perspective centre standard deviations */
double w,p,k; /* phi, omega, kappa orientation (deg. deg) */
double sw,sp,sk; /* phi, omega, kappa standard deviations */
double xo,yo; /* principle point (pixels) */
double f; /* focal length (pixels) */
double ky; /* y scale (unitless) */
double k1,k2,k3; /* radial lens distortion parameters */
double p1,p2; /* de-centring correction */

rotmat_type m;

} camera_type;

/* GEOFIT/VISAT structures */

typedef struct /* structure for the header file of images */
{
    long row; /* number of image rows ie. 480 */
    long col; /* number of image columns ie. 640 */
    long pixel_type; /* size of pixel (bits) ie. 8-bit, 16-bit, 24-bit */

    long image_numbers; /* number of images in this file */
    long date; /* YYMMDD - ie. 930513 */
    double t; /* GPS time */
    char frame[10]; /* Coordinate frame (ie. 3TM, UTM, WGS84) */
    char person_name[40];
    char company_name[40];
} header_type;

struct img_head
{
    header_type file_info;
    camera_type camera[6];
    char expand[474];
};

typedef struct img_head HEAD;

```